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THE INTERIOR OF THE EARTH.*

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THE additions that are being continually made to our knowledge of the composition and physical condition of the most distant heavenly bodies may well prompt one to ask why we are still so poorly informed concerning the constitution of the planet which the Creator has assigned to us for a dwelling-place. Mines and wells have barely scratched the solid crust that conceals the mysteries of the earth's depths. Our vague and uncertain ideas regarding the condition of the interior of the earth are based on analogies and inductions from facts observed on its surface or in the heavens. Very little light do we get on this subject from direct experiment. The bowels of the earth are not, indeed, easily accessible. Whatever the poet may say, the *descensus Averni* is not easily made; the domain of the stars is not thus hidden from us. For about two centuries large sums have been expended in the construction of gigantic telescopes with which to sound the depths of space; but no attempt, as a purely scientific undertaking, has been made to fathom the secrets of the underground world. The object of the numerous mines in different parts of the world has been simply the discovery of mineral riches, and the depths they have reached barely exceed, even in a few rare instances, a thousand metres; i. e., hardly the six-thousandth of the earth's radius—corresponding, on a globe thirteen metres† (about forty-two feet) in diameter, to a puncture one millimetre (about four one-hundredths of an inch) in depth.

Notwithstanding this paucity of positive data, it will not be unin-

* Translated from the "Revue des Deux Mondes," by Guy B. Seely.

† The length of a metre is about three feet three inches.

teresting to review the state of our knowledge on this obscure subject, and to show on what sides the question is accessible to science.

The form of the planets is itself an index, to a certain point, of the mode of their origin and their actual condition. These slightly flattened globes that wheel about the sun have been subject to the same laws that shape the drop of water and the grain of shot. It is impossible not to believe that they are specimens on a vast scale of the equilibrated form assumed by free fluid masses through the action of internal forces which assemble and unite their molecules. All these spheroids have been or still are liquid drops that have become flattened by reason of their rotary motion. Newton was led to infer the flattening of the poles from the idea that the earth had originally been in a liquid state, as the centrifugal force due to rotation tends to swell the equatorial at the expense of the polar regions. By the operation of the same force that impels a stone when swung in a sling to free itself, and that causes grindstones to burst when turned too rapidly, the particles of a revolving sphere tend to fly from the axis of rotation, and this centrifugal force, *nil* at the poles, increases as the equator is approached, and there attains its maximum intensity. The effect of this is to diminish weight, substances being a little less heavy at the equator than at the poles.

Imagine the earth completely liquid: the equatorial portion, driven by centrifugal force, will be elevated while the poles will be depressed. To better comprehend this, let us imagine a siphon, the two arms of which, joined at the center, issue, one at one of the poles and the other at the equator. The two liquid columns therein can remain in equilibrium, as the globe revolves, only on condition that the equatorial column, which is exposed to the action of centrifugal force, be longer than the polar column, which has lost nothing of its weight from this cause. The sphere becomes a flattened spheroid. This change of form can be demonstrated by turning rapidly on its vertical axis a sphere of clay or of flexible steel circles, as used in illustration of physics. As the pliant mass solidifies more or less completely, this flattened form is preserved.

That there is a discrepancy between weight at the equator and at the poles, more marked as we approach or recede from one or the other, may be shown by noting, by the tension of a spring, the weight of the same mass under different latitudes; but a more positive means of ascertaining this fact is furnished by the oscillations of the pendulum, which are retarded as the force of the earth's attraction diminishes. The astronomer Richer, having been sent to Cayenne in 1672 to observe the planet Mars, remarked that a timepiece regulated at Paris lost ten and a half minutes daily at Cayenne. It was this circumstance, at first inexplicable, that led Newton to suspect that the earth was a flattened spheroid.

It will be evident that an exact knowledge of the figure of the earth

has an important bearing on any hypothesis of the internal constitution of our planet. Geodesy, that science that may be called surveying on a grand scale, and which takes for its bases of measurement at once the earth and the heavens, has not yet completed its work. Since the labors of the Abbot Picard, to whom we owe the first measurement of a meridional degree, and the celebrated voyages of Bouguer and La Condamine to Peru, and of Maupertuis to Lapland, which confirmed the supposition of the flattening of the earth, there have been many other immense labors of a similar kind all over the world. The Société Géodetique Internationale, organized some years ago, is occupied in compiling and perfecting the results of these researches, and in deducing therefrom a provisionally definite result. We know with certainty that the form of the earth is not greatly different from that of a perfect sphere, for the flattening ascertained by geodetic measurements is, in round numbers, equal to $\frac{1}{300}$, from which it follows that the equatorial radius does not exceed the polar by more than twenty-two kilometres* (a little less than fourteen miles). This number, which represents the amount of the equatorial swelling, is equal to four and a half times the height of Mont Blanc, but, on a ball thirteen metres in diameter, the twenty-two kilometres in question would make an inequality of only two centimetres (about three fourths of an inch), and this would be totally imperceptible to the eye. The natural inequalities of the earth's surface are comparatively insignificant; the Alps and Himalayas, on a ball thirteen metres in diameter, would be represented by projections of a few millimetres only, and the greatest ocean-depths would not exceed one centimetre.

The question of the true figure of the earth is one of the most difficult of problems. From the time of Newton it had been held that the earth was a revolving ellipsoid—in other words, that the meridians were ellipses, and the equator and all the parallels true circles; and it only remained to determine the ellipticity of these meridians, all being supposed alike. It is now twenty years since Captain Clark's calculations, based on the uniformity of the great triangulations made up to that period in various parts of the world, led to the conclusion that the equator itself has an elliptic form, and that, consequently, the meridians are ellipses unequally flattened. According to Clark, the equatorial flattening is $\frac{1}{3270}$, or about one tenth of the average flattening of the meridians. This depression, amounting to two kilometres, occurs under the meridian passing, in the east, through the Sunda Archipelago, and in the west through the Isthmus of Panama, while the enlargement occurs under the meridian of Vienna, crossing central Europe and Africa. Thus, according to the calculations, the world is an ellipsoid with three unequal axes. This supposition can be made to harmonize with the hypothesis of the primitive fluidity of the earth, the form in question being one of those assumed by free liquids in

* The length of a kilometre is about five eighths of a mile.

rotation. It was found, however, that Clark's calculations were considerably affected by certain anomalies probably existing in some of the geodetic calculations employed, and it seems that a majority of those competent to judge in these matters endorse the theory of a revolving ellipsoid.

By the term "figure of the earth" is understood the geometrical form of an ideal surface coinciding with the mean level of the sea, and prolonged in thought beneath the continents. In fact, geodetic calculations are always reduced to the sea-level, the altitudes of the stations being first determined from levels based on the nearest coast-line. The great difficulty is to accurately determine this level for a given station. For a long time it was supposed that the surface of the open sea was a horizontal; in other words, that it was parallel to the surface of liquids in repose, and perpendicular to the direction of the plummet-line. But this definition is insufficient, as may easily be shown. The apparent vertical indicated by the plummet-line or determined at the level of the sea, is simply the direction of weight, which may be materially affected by local attractions due to an irregular distribution of the masses composing the soil. The vicinity of a mountain will deflect the plummet to a considerable degree, and a subterranean cavity may cause a deflection in the opposite way.

Let us now imagine the continents divided by a network of canals that connect all the seas, thus making of them one continuous sheet of water, as it were. Setting aside, for the purpose of the illustration, the oscillations caused by the tides, this sheet of water, assumed to be immovable, which represents the mean level of the sea, will exhibit elevations and depressions attributable to the local influences that deflect the plummet-line. The attraction of the continents causes a notable elevation of the sea-level along the coast, and a proportionate lowering of the mid-ocean. This influence of continents was described by M. Saigey in 1842, who gave as the probable height of the sea on the coasts of Europe thirty-six metres. Seven years later Mr. Stokes, the celebrated English physicist, attacked the question, bringing to bear upon it all the resources of mathematical analysis; and Philipp Fischer, in 1868, estimated that the disturbance of level due to the attraction of continents might amount to nine hundred metres. The mean level of the sea is, therefore, in all probability, an irregularly undulated surface, and the ideal or geometrical surface of the earth a regular spheroid, deviating but little from this average level, the accidental irregularity of which is in some way equalized.

The triangulations by which the terrestrial arcs are measured define the dimensions and configuration of this spheroid by the comparison of distances measured on the earth with the corresponding angular amplitude ascertained from the astronomical latitudes and longitudes of the stations. The most delicate part of the operations consists in ascertaining the local attractions that cause the deviations of the plum-

met. This difficulty is felt particularly in the Russian and Indian triangulations. While Colonel Chodsko found in the Caucasus a deflection of fifty-four seconds, and Schweitzer, in an open plain in the environs of Moscow, deflections of eight and nine seconds, the Himalayan chain appears to have had but an insignificant influence in place of the considerable one which the theory required—as if these mountains were composed of less dense rocks than the soil of the plain.

The operations referred to serve to indicate the form of the earth by the angles which the verticals of a series of stations—i. e., the direction of weight—make with the earth's axis. Another mode consists in measuring at numerous points the *degree* of the weight, and from this the distance to the center of the earth, the rate of oscillation of the pendulum being also noted. These oscillations are accelerated as the attractive power of the earth increases—that is, as the center is approached. We have seen that Richer remarked these variations of the pendulum in his voyage to Cayenne, and that Newton furnished the explanation of the phenomenon. At the commencement of the present century Biot, Sabine, Kater, Lütke, Foster, and others, made numerous experiments of this nature which have furnished a valuable verification of the results of geodesy, properly so called. But it must not be forgotten that the degree of weight may be changed by the same causes that change its direction. A local accumulation of very dense rocks may increase the terrestrial attraction, and light ones may diminish it. The de-leveling of the ocean of which we have spoken, by which the waters near continents are elevated while the mass of the ocean at large is lowered, results in making an ocean-valley, as it were, from which the islands, that are thus nearer the earth's center than the continents, project. This will explain the increased rate of oscillation of the pendulum observed in many islands, which is otherwise inexplicable.

The perturbations to which the direction as well as the degree of weight is subject have enabled us to determine the earth's mean density. The principle of the method is easily comprehended. Let us suppose that the deflection of the plummet has been measured near an isolated mountain whose volume and weight it is possible to estimate with some degree of precision. The amount of the deflection will furnish a means of calculating the relation of the mass of the mountain to that of the earth, and, the two masses being known, their relative densities can then be determined. The oscillations of the plummet at the summit and at the foot of the mountain afford the basis for a similar calculation. On carrying the plummet to the top some oscillations per day will be lost, the distance from the earth's center being increased; but the mountain's own attraction in part offsets the decrease in weight attributable to altitude, and herein we have the means of comparing its mass with that of the earth.

These methods were not neglected by Bouguer in his voyage to

Peru. Aided by La Condamine, he observed the variation in the plummet-line due to the influence of Chimborazo, and he noted the rate of the pendulum's movement on the volcanic mountain of Pichincha (which is equal in height to Mont Blanc), and at the sea-level. Unfortunately, the imperfection of his instruments, the rigor of the climate, and the violence of the winds, prevented the two French astronomers from attaining great precision in these observations. The effects they had expected to see confirmed were found to be much less marked than they had anticipated, and Bouguer therefore believed that the volcanic mountains of Peru were hollow and internally simply huge caverns. A repetition of his experiments, with the care required in researches of such a delicate nature, would determine the question whether the unsatisfactory character of his results was due to errors of observation, or if it was a case similar to that of the Himalayan chain.*

Bouguer's method was employed successfully in 1774 by the celebrated English astronomer Maskelyne. He chose for his experiments Mount Schiehallion in Scotland. This mountain is wholly isolated. Its geologic constitution is known, and its form is not very irregular; the calculations were thus simplified. By observations of the stars that passed near his zenith Maskelyne first determined the latitudes of two stations, one to the south and the other to the north of the mountain—the distance between them being 1,330 metres. The difference in the two astronomical latitudes was found to be 43″ instead of 54″.6, as shown by the measured distance. The excess of 11″.6 represented the sum of the attractive force exerted by Schiehallion on its opposite sides. It then remained to ascertain the volume of the mountain, its exact configuration, density, and total weight, and by the aid of these factors to determine the theoretic sum of the attraction it exerted on the plummet of the two stations. The geologist Hutton was intrusted with this work, which occupied him three years. The result of his calculations was, that the deviation observed would be explained by supposing the mean density of the mountain to be to that of the earth as 5 is to 9. Hutton first adopted for the density of Schiehallion the number 2·5—about the density of quartzose sandstone; according to this the mean density of the globe was 4·5. He afterward modified these figures, taking 3·0 for the density of the mountain and 5·4 for that of the earth. The geological study of this mountain, undertaken subsequently by Playfair and Lord Webb-Seymour, showed the density of its component rocks to be intermediate between these two estimates, from which it would appear that the earth's density is 4·7.

These experiments were not supplemented by observations of the

* M. Saigey has shown that, by selecting from Bouguer's observations those which appear to have been made under favorable conditions, and by calculating the force of the attractions in a more exact manner, the density of the earth is found to accord with Maskelyne's estimate of it.

pendulum's oscillations; it is true the mountain's slight elevation—one thousand metres—did not promise a very marked effect. An experiment of this kind was made in 1821 by the astronomer Carlini, on Mont Cenis, which showed the earth's density to be in the vicinity of the number given by Maskelyne. In 1854 Airy performed an analogous experiment at the bottom of the Harton coal-mine. At a depth of 1,220 feet it was demonstrated that the seconds pendulum advanced in speed two and a quarter seconds per day, and from this it was concluded that the mean density of the globe is to that of the surface as 2·63 to 1, and, taking the density at the surface to be 2·3, that of the globe is 6·1. M. Saigey endeavored to find the density of the globe by the deflection of the plummet-line due to a whole continent's attraction, calculating the theoretic deviation from the vertical at Evaux, a central point of France, and one of the stations of the meridian of Paris. According to Puissant's calculation, there exists between the astronomical and geodetical latitudes of Evaux a difference of about 7″, which would indicate that the attraction of the southern part of France, i. e., to the south of the latitude of Evaux, exceeds that of the northern portion. Now, with a good orographic chart the average elevation of the ground from about Evaux to the Pyrenees, the Alps, and to the neighboring seas can be calculated, and with these data the effect of all the partial attractions that affect the plummet-line at Evaux. M. Saigey has shown that, to account for the discrepancy pointed out by Puissant (who supposes the attraction of the globe to be about 30,000 times greater than that of all France above Evaux), the mean density of the earth must be to that of France alone as 1·7 is to unity. Taking 2·5 for the density of the ground, as compared with water, it gives 4·25 as the density of the globe.

The researches of Maskelyne, above referred to, may be reduced to a closet experiment: one can weigh the earth in his own room! This was first done by the illustrious Cavendish. This, the youngest, son of the Duke of Devonshire, who sacrificed his hopes of fortune to his love of science, commenced his career in poverty. "His parents," M. Biot tells us, "seeing that he was good for nothing, treated him with indifference, and gradually became estranged from him. He made amends by becoming one of the first chemists of his time, and, when he had acquired celebrity, one of his uncles, who had been a general abroad, returned at a happy moment to leave him an inheritance of three hundred thousand francs rental. He also left him at his death a fortune of thirty million francs. Cavendish was thus the most wealthy of all the learned, and probably the most learned of all the wealthy."

Cavendish had received from Hyde-Wollaston an apparatus which he in turn had obtained as a bequest from John Michell, and which was designed to determine the weight of the earth by the attraction exerted by two large globes of lead on two small balls suspended from

the ends of a movable lever. There was certainly something novel and *bizarre* in this idea of attempting to observe the attraction of a ball of lead, which we are accustomed to consider an inert mass—in trying to demonstrate by *sight* its infinitesimal share in universal gravitation. It was accomplished, nevertheless. Cavendish improved Michell's apparatus by applying to it the principle of the famous torsion balance of Coulomb—the torsion of a wire opposed as a moderate force to the attraction exerted on a lever carried by the wire. His experiments were communicated to the Royal Society of London in 1798. The mode of making the observations is easily described. A horizontal lever of fir-wood was suspended to a metallic wire dependent from the ceiling of a closed chamber. At its two extremities were two small balls and two blades of ivory, marked with divisions. All the movements of the lever were observed from without through lunettes fixed in the walls of the chamber, and directed toward these divisions. Finally, two large globes of lead, each weighing 158 kilogrammes and sustained by a screw-gauge, could be moved toward or from the balls at will, by mechanism worked from the outside. Now, whenever they approached the small balls the latter were seen to obey the attraction of the globes of lead; they were displaced, and oscillated around a new point of equilibrium where the reaction of the torsion wire counterbalanced the attraction of the globes. From these experiments and the ascertained strength of the attraction of the globes in relation to their weight, it is easy to estimate the relation of the mass of the globes to that of the earth, and thence the density of the earth. Cavendish thus found the earth's density to be 5·48, that of water being unity.*

Cavendish's experiments were repeated by F. Reich, at Freiberg, in two trials in 1837 and 1849, and also at London in 1842, by Francis Baily, under the auspices of the Astronomical Society. Reich's figures differed but little from Maskelyne's (5·44 to 5·58). Baily's experiment gave a little larger figure (5·67). Baily improved upon the apparatus of Cavendish in several ways: he changed the size and material of the small balls, using balls of platinum, lead, brass, zinc, glass, and ivory. The figure he settled upon was the average of over two thousand tests; still, it is not wholly reliable, his results being affected by certain errors the cause of which was for a long time unknown. The question was of an importance that warranted a re-examination of the data with all the resources of modern science. Two French physicists, A. Cornu and J. Baille, have recently accom-

* The considerable difference between this number and that furnished by Maskelyne's observations induced Hutton, then advanced in age, to examine anew Cavendish's experiments. "I could not," he says, "rely on these results without repeating the entire computation. Still, after a long life spent in abstract researches, being now eighty, and overwhelmed with infirmities, I feel that I may be pardoned for shrinking from the task. But I should have no rest were I not myself to undertake the work." Hutton discovered many small errors in calculation, and he found 5·31 to be the measure of the earth's density.

plished this work. Their experiments, commenced in 1870, have been the subject of various interesting communications to the Academy of Sciences. Their apparatus are deposited in the vaults of the Polytechnic School. They are much smaller than those of Cavendish and Baily, for, as Messrs. Cornu and Baille have remarked, there is an advantage gained in these experiments by reducing the dimensions of the apparatus. The attracting mass, formed of mercury contained in two hollow spheres of bronze, 0·12 metre in diameter, weigh twelve kilogrammes. By transpiration the mercury can be made to pass from one sphere to the other, thus doubling the effect of the attraction, and this change is effected without shock or disturbance.* The lever of the torsion-balance is a little tube of aluminium, 0·50 metre in length, carrying at each end a ball of copper weighing one hundred and nine grammes. A flat mirror fixed in the middle reflects the divisions of a horizontal scale five or six metres distant, and the slightest movement of the lever is thus revealed by a displacement of the scale divisions. The time of a double oscillation of the lever is about seven minutes. The phases of these oscillations are registered by electricity. A great merit of these researches consists in the opportunity they afford for a thorough study of all the causes of perturbation that can introduce error into such experiments. The definite result can be accepted with confidence. The figure thus far obtained is 5·56. It may be added that Messrs. Cornu and Baille have discovered the cause of the too large number given by Baily. In correcting the errors of system in his experiments, it is probable that a slightly different number will be obtained—5·55. To sum up, the earth's mean density thus appears to be five and a half times that of water, and the density at the surface is less than half that of the interior, or about 2·5. Consequently there must be in the interior heavy masses whose excess of density compensates for the lack thereof in the rocks at the surface. This need not be surprising, for the heavy pressure sustained by the deeper strata must naturally increase the density. But what is the law governing this increase of density from surface to center? Legendre formulated a simple law, adopted also by Laplace, according to which the surface density is 2·5, at the middle of the radius 8·5, and at the center 11·3, the mean being taken as 5·5. A different law, to which M. Edouard Roche arrived by theoretic considerations, gives a surface density of 2·1, a mid-radius density of 8·5, and 10·6 at the center. This agreement of results deduced from three different hypotheses shows that the decision of the question is narrowed to small dimensions. Adopting M. Roche's conclusions as the most probable, it can be said that the mean density of the earth is about double that of its surface, and that the density of the center is double that of its mid-radius. The central strata or masses have a density approximating to that of lead.

* In the later experiments the number of the spheres was doubled.

The fact of an elevated temperature in the depths of the earth can no longer be doubted, though the law according to which the heat increases as we descend below the surface is still far from being perfectly understood. As early as the seventeenth century Father Kircher mentions the subterranean heat that was felt at the bottom of mines.* Boerhaave and Boyle also make mention of observations concerning the heat existing in the center of the earth. Still, it was not until 1740, nearly a century and a half after the invention of the thermometer, that a serious attempt was made to measure this heat. This was first done by Gensanne, director of the lead-mines of Giromagny (Vosges), who lowered a thermometer to a depth exceeding four hundred metres, and proved that the temperature increases at the rate of one degree to nineteen metres. Toward the end of the century Horace de Saussure, desiring to ascertain whether the earth's proper heat had any effect on the melting of glaciers, made a similar experiment in the salt-mines of Bex, and found the rate of increase to be 1° to 37 metres. Many similar experiments have since been made; it will suffice to cite the most important.

Cordier, in his celebrated "Essay on the Temperature of the Interior of the Earth," read at the Academy of Sciences in the year 1827, compiled the results of his predecessors' researches in this matter and those obtained by himself in certain mines. In the mines of Carmeaux (Tarn) he found an increase of 1° to 36 metres, 1° to 19 metres in the mines of Littry (Calvados), and 1° to 15 metres at Decize (Nièvre). The average of his compilations is 1° to 25 metres. From these investigations he concluded that at a depth of some hundreds of kilometres the heat must be 100° of Wedgwood's pyrometer—sufficient to fuse lava.

To arrive at trustworthy results, it is not enough to observe merely the temperature of the air at the bottom of a mine, or that of the water that penetrates the adits, but the thermometers should be placed in cavities made in the natural rock, and left there a sufficient length of time to allow them to acquire the temperature of the surrounding medium. The currents in the air of mines lower the normal temperature, particularly by producing an evaporation of the moisture in the rock, and it thus happens in some mines that the temperature of the air is lower than that of the surface-air, as is the case in the Maestricht quarries. The heat due to the presence of workmen modifies the effect of this in a measure. It is estimated that in a gallery 4,650 metres long, and two metres high by one wide, the temperature will be raised 1° by ten men, each furnished with his lamp. As regards the water found in the adits, it is evident that they will not indicate the mine's true temperature unless they remain in it for a considerable time, for the water infiltrated from the surface, or coming from springs at certain depths, may be either warmer or colder than the rocks

* "Mundus Subterraneus," 1664, vol. ii.

through which they percolate. The most reliable way, therefore, is to place the thermometers in cavities of the rocks in the mines, and also in the angles of the cuttings, where the rock is newly hewed, and still uncooled by contact with the air. Cordier pierced the rock for this purpose to a depth of 0·65 of a metre. Reich, who made a large number of observations in the mines of Erzgebirge, bored to the depth of a metre, using thermometers constructed for the purpose, with long stems projecting from the orifices in the rock, which were then packed with sand. These investigations were continued from 1830 to 1832, in twenty different mines, scattered over many square leagues. The thermometers were ranged as far as was practicable in a vertical line, at depths varying from 20 to 350 metres, the markings being taken twice or thrice weekly. From these observations it was found that the depth corresponding to an increase of 1° Cent. was 42 metres.* In the Ural mines in Siberia, Kupper showed that a far more rapid rate of increase existed—1° to 20 metres—while in the mines of Prussia the rate was found to be much less rapid—1° to 57 metres, according to Gerhard. In certain isolated cases a far greater divergence is seen. It, moreover, appears to be established that the heat increases more rapidly in coal-mines than in metal mines, and in copper than in tin mines, and in the metalliferous rocks generally more rapidly than in the schists, while in granite the increase is more gradual than in any of the preceding. These differences are no doubt due to the greater facility with which certain earths conduct heat, and perhaps to chemical phenomena of which they are the seat.

It must also be said that in many cases the rate of increase, far from being uniform, appears to slacken as the greater depths are reached. Thus, according to Fox, the observations made in the Cornwall and Devonshire mines show a difference of 1° Cent. to 15 metres, down to a depth of about 100 metres, and 1° to 41 metres at a depth of 350 metres. This decrease is also very marked in the famous Tcherguine pit in Yakutsk, which is in completely frozen soil. Commenced in 1848, at the expense of a merchant named Fedor Tcherguine, who expected to find water at a depth of 10 metres, this pit was sunk in three years to a depth of 35 metres, still in frozen ground, and the work would have been abandoned if, happily for science, Admiral Wrangel, on a voyage to Yakutsk, had not represented to the proprietor the interest the undertaking would have in its bearing on the physics of the globe. It was therefore excavated for six years more, reaching a depth of 116 metres. Even there the earth was still frozen, and the work was finally abandoned in 1837, and the pit was carefully covered. In 1844 Middendorf visited it, and made a series of thermometric observations, according to which the mean temperature was found to be, at a depth of two metres, 11·2° ; at 60 metres, 4·8° ; and

* Only those observations made below twenty metres from the surface, where the temperature does not vary with the seasons, were taken into account.

at the bottom, 116 metres, 3°. It was thus seen that, whereas the rate of increase from the surface to 60 metres in depth was 6·4°, for the remainder of the depth, 56 metres, it was only 1·8°.

The experiments made in artesian wells have given analogous results—that is, wholly irregular as regards the rate of increase of temperature. The mean of 27 observations in Vienna is, according to Spasky, 1° to 20 metres. The very accurate experiments of Magnus, in 1831 at Rüdersdorf, near Berlin, on the occasion of the boring of an artesian well, yielded the same result, but at Pregny, near Geneva, Messrs. Rieve and Marcet found the depth corresponding to an increase of 1° Cent. to be 32 metres. The well was sunk 220 metres. This figure represents sufficiently exactly the average rate of increase of temperature resulting from thermometric soundings made in artesian wells. Walferdin found an increase of 1° to 31 metres in the artesian wells of the Military School at Paris, in that at St. André (Eure) and in the well of Grenelle; and many others have given figures comprised between 30 and 35 metres for the difference of level representing a difference of 1° in temperature. The temperature of the water of the Grenelle well, 548 metres deep, and of the Passy well, 570 metres deep, is 28°, while the mean temperature of Paris is 10·6. These waters, therefore, receive from the deep strata an addition to their temperature of a little more than 17°; i. e., a little more than 1° to each 32 metres of depth. The much deeper borings of Musalweek, near Minden in Prussia, 700 metres, and of Mondorf in the grand duchy of Luxemburg, 730 metres, show a difference of 1° to 30 or 31 metres.

From a comparison of the temperatures observed by Walferdin near Creuzot, at the bottom of a boring 816 metres deep, and in a neighboring well 554 metres deep, it also appears that at these depths the heat increases more rapidly than at the surface. But wells situated very near each other may give widely varying results. Thus at Naples, according to M. Mallet, in two very deep artesian wells, distant from each other 1,600 metres, the depths corresponding to 1° of additional heat were 45 and 109 metres respectively.

The observations of M. Mohr, in 1876, in a well 4,000 feet deep, pierced through a salt-rock at Speremberg, near Berlin, led this physicist to believe that the rate of progression sensibly slackens as we descend below the surface—a conclusion agreeing with Fox's deductions from observations in the English coal-mines. M. Mohr remarked that from 700 feet, where the glass marked 19·6° Cent., to 3,300 feet, where it marked 46°, the difference in temperature corresponding to a difference of 100 feet, diminished in a regular ratio, so that, continuing the sounding, beyond 5,000 feet only a barely perceptible increase could be observed. But M. A. Boué, who warmly contested M. Mohr's conclusions, has observed with reason that percolated water will frequently lower the temperature of these deep beds, and this would explain the diminution observed by M. Mohr.

In this class of researches thermometers *à déversement* are used, the reservoirs of which overflow as the temperature rises; the mercury remaining in the ball shows the maximum attained. Walferdin's registering thermometer and the geothermometer of Magnus are constructed on this principle. Thermometers *à minima*, of a different construction, are used to determine the temperature of the ocean-depths, which are generally colder than the water at the surface. The many soundings made by the English scientific expeditions established beyond a doubt the fact that the temperature at the bottom of the sea is often but little above zero. This would be explained by supposing the colder water to be carried to the bottom by its specific gravity, the water warmed and dilated by the sun's heat remaining at the surface. The bed of the ocean at large, where the normal temperature is not affected by warm currents, such as the Gulf Stream, may be said to be covered with water at the freezing-point. The water at the bottom of fresh-water lakes is less cold because the maximum density of fresh water is 4°. It results from this that the portions possessing this temperature are carried to the bottom, while the colder or warmer portions rise to the surface. Thus, that portion of the earth's shell that is covered by water remains at a relatively low temperature, in consequence of the stratification resulting from the varying densities of the liquid, but, if it were possible to carry on in the bed of the sea such investigations as have been made on land, an increase of temperature, such as has been proved to exist in the frozen soil of Siberia, would doubtless be found.

The increase in heat as we descend is generally admitted to average 1° in 30 metres. If this rate is constant it is clear that, at a depth of 2,700 metres, the temperature must equal that of boiling water; and that, at a depth of 50 kilometres, the heat must exceed 1,600°, a point at which iron and the greater part of the rocks would melt. This is the principal ground for the argument of those who maintain that the earth's crust is not more than 40 to 50 kilometres thick—or, relatively to its size, of the thickness of an egg-shell compared with the egg. Certain it is that the increase of heat with the depth, confirmed by so many observers, perforce gives a warrant to the idea of a subterranean fire possessing an inconceivable degree of heat; but the question is, At what depth from the surface does this fire exist?

The thermometric observations thus far made are insufficient to decide this question. Among the mines that have reached a great depth may be mentioned those of Kitzbühel in the Tyrol (900 metres); Kutteuberg in Bohemia (1,200 metres); Mouille-Louge (920 metres); and Speremberg (1,260 metres). Why may not borings be made at the bottom of some of these very deep mines, by means of which the bowels of the earth can be still further penetrated?

It is also desirable that the natural cavities in the earth should be utilized for scientific investigation. The accounts contained in the

old books that relate to this matter are unfortunately filled with exaggerations, and the lack of recent evidence prevents our extracting from them the portion of truth they perhaps contain. Pontoppidan, in his "Natural History of Norway," describes a cavity in the vicinity of Frederickshall, in which the duration of the fall of a stone appeared to be two minutes. Assuming, says Arago, that the stone fell clear, without hitting and being retarded by projections in the walls of the cavity, the total depth indicated by its two minutes' fall would be over 4,000 metres, exceeding by 800 metres the height of the highest mountain in the Pyrenees. But it would appear that the noise of the stone's falling was heard for two minutes—that it consequently rolled and bounded from point to point; and modern travelers have nothing further to say of the famous Frederickshall hole. Another account, of the legendary cavern of Dolsteen, in the Island of Herroe, Norway, is likewise doubtful. According to a belief among the inhabitants, this cavern extended to and under Scotland. It is told that, in 1750, two priests ventured far into it and heard the rumbling of the sea above them. Coming to the brink of a precipice, they threw over a large stone, which was heard to fall a minute after. Without, however, attaching importance to accounts from such unreliable sources, it may still be admitted that natural cavities exist which might be made use of in exploring the deeper strata of the earth's crust. M. Babinet, who cherished the idea of forming a society for digging a deep hole for such purposes, thought the question had its industrial side which ought not to be lost sight of. "This is no longer," he somewhere says, "the time of Voltaire, who so bitterly berated Maupertuis, whom he described as having wished to pierce the earth that we might see our antipodes by leaning over the edge of the well of this antagonist of the irascible king of literature. Nobody would today deny the possibility of sinking the shafts of mines to a depth of several thousand metres, when we have such choice of ground, dimensions, and, above all, time. Let us suppose that we have reached a depth of four kilometres only, and cleared a suitable space. If men can not support the heat, machines, which are not so delicate, can. We see ourselves in possession of a vast space, the walls of which are of the temperatures of our ovens and stoves. Conducting thereto a stream of water, it issues hotter than boiling water, and is a veritable mine of heat, as truly so as are the precious coal-mines of England and Belgium." It is a fact that the heat of the springs of Chaudes-Aigues, which reaches 80°, is made use of by the inhabitants for purposes of cooking, heating their houses, washing, etc. By conduits of wood, in all the streets of the village, reservoirs on the ground-floor of each house are supplied, and these serve the purpose of heating-stoves in cold weather, fires and chimneys being dispensed with. In summer, the inflow is stopped by little sluice-gates at the inlet of each supply-pipe, the water then flowing to the brook at the border of the

village. M. Berthier, the chemist, has estimated that the heat furnished daily by these springs equals that produced by the combustion of more than four and a half tons of coal, sufficient to comfortably warm the houses and even the streets.*

Now that the rapid exhaustion of coal-mines forces man to seek the precious combustible at increasingly greater depths, it interests us to know the extreme limit of accessible depth. The report of the English commission of inquiry contains very complete data on this point.† The sole cause, says the report, that can place a limit on the practicable depth of mines is the elevation of temperature. In the English mines the temperature is of marked uniformity to the depth of about 15 metres, viz., 10° Cent. From that depth the heat increases at the rate of 1° to 37 metres, so that at a kilometre of depth it attains blood-heat. This heat hinders the mining operations by heating the air that is artificially made to circulate in the mines, and rendering its effect insignificant. Regarding the question of the highest temperature man can work under without danger to health, the evidence gathered by the commission exhibits some extraordinary cases, but such of them as were verified were found to be exaggerated. Competent authorities are, however, united in maintaining that steady labor is impossible, in humid air, at a temperature approaching 37°. Heat is better supported in dry air. Now, as the deepest mines are generally the least humid, we ought, with the powerful means of ventilation available in these days, to certainly reach a depth of 1,200 metres. We may perhaps go even deeper, thanks to the system of atmospheric shafts recently introduced at Epinac by a French engineer, M. Z. Blanchet. By means of a pneumatic tube the cars are propelled and a thorough ventilation is secured at the same time. By developing this system, very deep deposits can doubtless be reached.

[*To be continued.*]

CHANGES OF THE CIRCULATION DURING CEREBRAL ACTIVITY.

By CHARLES SEDGWICK MINOT, S. B., S. D.

DR. ANGELO MOSSO, the distinguished Professor of Physiology at the University of Turin, has made some observations on the physiology of the brain which, for novelty and interest, have been equaled by but few recent scientific discoveries; for his researches lie

* Elisée Reclus, "La Terre," vol. i, p. 239.

† See in the "Revue" for October 1, 1876, an article on the "Coal Production of England and France."

in the debatable land between physiology and psychology, and have contributed to the advance of both sciences.

The history of these discoveries illustrates in a very striking manner the unexpected developments to which scientific research sometimes leads. In 1873–'74 Dr. Mosso experimented in the laboratory of Professor Ludwig, at Leipsic, upon the circulation of the blood through the kidney. He took advantage of the fact that death is a double process: 1. The death of the animal as a whole, or that which we ordinarily call death; and, 2. The subsequent and gradual death of the tissues, to which is due the curious phenomenon that an organ survives the animal of which it has formed a part. The most remarkable and familiar instance of this is the heart of the frog or turtle, which may continue to beat, for several days even, after the animal to which it belonged has been killed. So also the vitality of the kidney may be preserved by proper precautions for a considerable period. The organ *overlives*, as it is expressed in German. To physiologists this overliving of tissues is of the utmost value, because it enables them to perform numerous experiments that would otherwise be difficult or impossible, which latter alternative would have been the case with Mosso's researches upon the renal circulation.

Mosso's experiments were briefly as follows: Their connection with the subject of this article will appear directly. The kidney was taken from a dog immediately after his death, and glass tubes inserted into the artery and the vein, so that blood could be passed through the former into the kidney, under any desired pressure, sufficient to force it through the vessels of the organ into the vein, whence it could pass out by the glass tube, and be collected in a receptacle. It is unnecessary to describe the details of the experiments—the ingenious devices adopted to prevent the drying up of the kidneys, or irregularities of the pressure of the blood; in short, to eliminate those conditions which might disturb the accuracy of the results. Let it suffice to say that the kidney after its removal from the body was found to preserve its vitality to a fuller extent than had been previously supposed. The especial result of Mosso's experiments was the demonstration of the alterations of the circulation which take place in a single organ independently of the central nervous system, from which the kidney was of course entirely severed. It was noted among other things that the capacity of the blood-vessels altered: under one set of circumstances the kidney held more, under another less blood. This could be detected in two ways: first, when the capacity increased, more blood would enter the artery than flowed out from the vein, or, if the capacity diminished, more would flow out than in; and, second, by changes in the volume of the kidney. The latter method was the most valuable, because the changes in the volume could be actually measured. This was accomplished by placing the kidney in a glass case filled with oil. The tubes for the artery and the vein passed out through the side of the case.

Through a third hole passed a horizontal glass tube. Now, when the kidney increased in volume it drove the oil into the horizontal glass tube, when it contracted the oil was sucked back again—hence by measuring the distance the oil advanced or retreated, the corresponding increase or diminution of size of the kidney could be exactly determined.

The physiological importance of the changes of the volume of a single organ was thus clearly established. If it was possible to record those changes in an isolated organ, why not try to record them of a part, a limb still connected with the body? The possibility conceived was soon accomplished. The apparatus was altered and improved. In its new form it could be used to record the changes in the volume of the human forearm by tracing them upon a piece of paper in the shape of a series of curves.

The construction of the apparatus, as finally adopted by Mosso, is shown in the accompanying woodcut, copied from the original memoir* of its inventor, who calls his instrument a *plethysmograph* (*pletismografo*), because it writes the filling (*plethusmo*) and unfilling of an object.

The apparatus consists of—

1. A glass cylinder, A B, forty-eight centimetres long and eight or ten in diameter, open at one end, and terminating in a small neck at the other. It is furnished with two openings, C and D, which serve to fill it with water and to introduce a thermometer. These openings may be closed with corks. The arm of the person to be experimented upon is introduced into this cylinder.

2. A broad ring at A of vulcanized rubber to fit around the end of the cylinder and around the arm introduced into it, so as to form a water-tight joint.

3. A board, E, suspended from above, and serving to support the glass vessel, with the included arm.

4. The recording instruments. These have a difficult office to perform, for they must register the changes in the volume of the limb. The forearm is placed in the cylinder A B, which is then filled with water; when the arm swells, the water is driven out through the rubber tube F; when the arm shrinks, the water is sucked back. Now, it is the amount of water expelled or drawn in which is to be measured—this is accomplished by the following means: The rubber tube F opens into a glass tube G, which, bending at right angles, descends to the level *a b* of the liquid contained in the large beaker P. The descending limb is perfectly vertical, and securely fixed in that position by being fastened to an iron support. A thin-walled test-tube, M, about eighteen centimetres long, is suspended by two silk threads from the double wheel L, and balanced by a counter weight N, which also car-

* "Sopra un nuovo Metodo per scrivere i Movimenti dei Vasi Sanguini nell' Uomo." "Atti della Reale Accademia delle Scienze di Torino," vol. xi (November 14, 1875).

ries a kymographic pen, suitable for drawing a line upon a sheet of paper drawn past the point of the pen by a clock-work constructed for that purpose.

The test-tube M is so hung that its axis is traversed by the vertical descending limb of the glass tube G, and the test-tube can move up or down without striking the tube occupying its center.

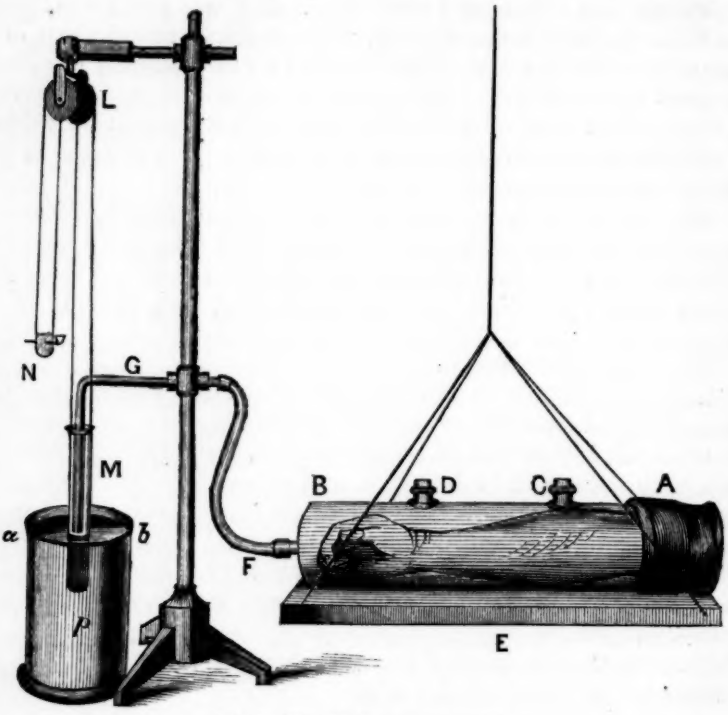

FIG. 1.—MOSSO'S PLETHYSMOGRAPH.

If, now, the glass cylinder containing the arm and the tubes F and G are filled with water, and the arm begins to expand, then the water will be forced out into the test-tube M, which will therefore descend into the fluid in the beaker, P, raising, as it descends, the counter-weight and pen, N. If, on the contrary, the arm contracts, the water will be sucked back, the test-tube M will be lighter, the counter-weight will pull it back, and the pen will descend. Let us suppose that the point of the pen rests against a sheet of paper which is being drawn along horizontally with a constant velocity. As long as the pen is stationary it will draw a horizontal line ; if it ascends, it will draw an ascending curve ; when it falls, a descending curve. Such a line is technically termed a tracing. It shows the extent and duration of the motion, and exemplifies one of the many applications of the graphic

method. The horizontal distances, since they are determined by the rate at which the paper moves, correspond to the time. For example, if the paper moves an inch per minute, then, if we measure up a horizontal line the number of inches along which the tracing continues to rise, we can fix the points corresponding to a given time, and measure the height to which the pen had risen at any given instant, and also the rate at which it rose.

The vertical motion of the pen depends on the rise and fall of the test-tube M, which in its turn is caused by the out- and in-flow of the water surrounding the arm. Hence, a rise in the curve corresponds to an expansion, a fall to a contraction of the forearm. There are other details and precautions in the construction and use of the apparatus requisite to secure entire accuracy, for which I must refer to the original memoir. Modifications of the apparatus have been made by Ludwig and Kronecker, and a very essential improvement has been suggested and used by Dr. H. P. Bowditch, of Boston. These improvements are important to the experimenter, but have only a subsidiary interest for the general reader. The plethysmograph can be employed for many purposes. For example, it may serve as a very perfect thermometer, by applying it to record the changes of a closed volume of air, which of course increases or diminishes according as the temperature rises or falls.

With the aid of the plethysmograph Mosso discovered that the activity of the brain is directly connected with the circulation of the forearm. The importance of this fact will be better understood, if it is considered that we here have a physical phenomenon we can accurately measure, directly connected with mental phenomena we can not measure.

It is well known that the functional activity of an organ of the human body is accompanied by increased activity of the circulation, and this is also true of the brain. Since the total amount of blood is not subject to rapid and sudden changes, it is evident that, when an active part receives more blood, other parts must receive less. When the brain is at work, blood is withdrawn from the arm, which therefore becomes smaller.

In order that the volume of the forearm should remain constant, absolute tranquillity is necessary ; the slightest movement of the mind suffices to disturb the equilibrium of the vascular system. The plethysmograph is an instrument with which we can record even emotions not depicted by any expression of the countenance, or revealed only by unnoticeable changes in the beating of the heart or of the respiratory movements. "Therefore," says Mosso, "I think it my duty to commence with a tracing that represents the sentiment of veneration which I felt in the presence of my beloved master. Behold, in fact, the contraction of the vessels produced by the entrance of Professor Ludwig, every time he honored the researches made upon myself with

a visit." I have translated as literally as possible Mosso's words—those unfamiliar with Italian should remember that words like "veneration" and "master," when rendered literally, convey a more fervid feeling in English than is expressed by the original. We reproduce the tracing referred to; the upper line is drawn by the pen, and its descent corresponds to the diminution of the volume of Mosso's right forearm; A marks the point when Professor Ludwig entered. The lower line records the time, each notch corresponding to an interval of five seconds. The diminution of volume was equal to about six

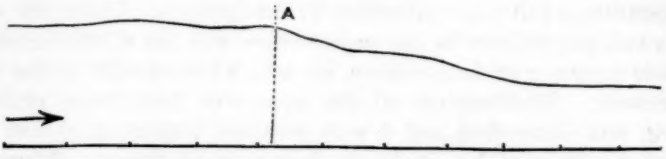

FIG. 2.—CURVE TRACED BY THE PLETHYSMOGRAPH, showing the diminution of size in the forearm, produced by the emotions caused by Ludwig's entrance at A.

cubic centimetres. This effect was not due to any strong emotion of fear or anxiety, but merely to the affectionate respect which Professor Ludwig's genial manners win from his pupils. The same experiment was tried upon Dr. Pagliani, with the same result.

Cerebral activity, like all the emotions, is reflected by the vascular system. To test this, the person experimented upon was given some simple arithmetical problem to solve; this was chosen because it could be solved without the person's speaking, which would have necessitated a change in the respiration, and so have modified the circulation. Fig. 3 shows the effect of calculating 245×15. The lines as before. This experiment was made upon Dr. Frey, and testifies to the great effect of a comparatively light and brief mental labor. It appeared that the

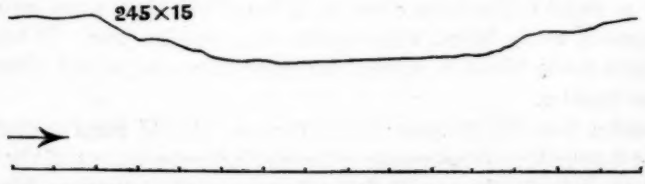

FIG. 3.—CURVE TRACED BY THE PLETHYSMOGRAPH, showing the diminution of size in the forearm of Dr. Frey, produced by his calculating 245×15.

more complicated the sum to be solved the longer and greater was the contraction of the arm. The response of the circulation is very ready and marked, and, in persons of excitable temperaments, strong effects are produced from such very slight causes that it is sometimes difficult to make any experiments upon them.

There is undoubtedly a relation between the intensity of the emo-

tion or mental process and the change in the circulation. This is illustrated in the following curious experiment upon one of Mosso's friends, who was a student of literature: While his arm was in the apparatus, Mosso presented to him a few pages on which were pasted paragraphs in Greek and Italian indiscriminately. By watching the changes in the volume of the arm, Mosso was able to decide correctly when his friend was reading a Greek paragraph, because to the greater mental effort corresponded a greater contraction of the vessels.

But the amount of blood in the extremities varies not only with psychical but also with physiological activities—for instance, with the respiration. The size of the forearm was shown by the plethysmograph to diminish during a deep inspiration, to increase during a prolonged and powerful expiration; or, again, alterations may be called forth by irritation of the skin of the arm, or even of a distant part of the body, or by direct compression of such of the veins or arteries of the upper arm as do not lie too deep to be reached, or even by changing the position of a limb other than the one being experimented upon. In brief, an almost endless variety of circumstances affect the circulation of a given part, as shown by the changes of its volume; but, among these circumstances, the condition of the brain is especially influential.

Mosso, however, has not confined his investigations to the waking condition, but has extended them also to men asleep, thus discovering a very great increase in the volume of the forearm as a person gradually falls asleep. The large size of the forearm during sleep may be diminished by a dream, or by any cause that renders the sleep less profound. It was evident that persons hear in their sleep various sounds, which disturb their slumbers but do not wake them up. When his friend was asleep, Mosso saw him move as a dog near by barked, and at the same time the apparatus recorded a diminution in the size of the extremity. Observation in this case shows that the cerebral activity during sleep is much greater than is usually supposed, and that a person may dream, as is evident by his moving or making some sound, yet have no recollection of it upon awaking. The plethysmograph preserves a more accurate record, for the slightest movement or disturbance produces its effect upon the arm, diminishing its volume. As a person awakes naturally, the size of the forearm is gradually lessened, because the blood is withdrawn.

To summarize the result: whenever the brain acts in any way, blood is withdrawn from the arm and from all the extremities; when the brain is inactive, more blood circulates in the limbs, most during sleep.

By the same apparatus, Mosso also discovered that the circulation was changed by a dose of chloral very nearly, if not exactly, as in natural sleep; and that this drug, tested by these phenomena, produced a slumber very similar to normal sleep.

Pursuing his researches in other directions, Professor Mosso has succeeded in demonstrating that, when the brain acts, not only does the arm receive less blood, but the brain actually does receive more. This result was, of course, to be anticipated ; and in making this further observation Mosso is not the first, for other physiologists have published researches upon this point, only less accurate and complete than those of the distinguished Italian investigator.

Opportunities for observing the circulation of the human brain are very rare, and occur only in consequence of violent accidents or insidious diseases, causing a loss of a piece of the bony skull sufficient to leave the soft brain exposed. Through such an opening it can be observed that the soft brain is smaller during sleep than during waking, because during the former state it draws back from the opening, and during the latter it may swell so much as even to protrude through the opening. That these changes are not abnormal results due to the diseased condition, is shown by the experiments which have been made upon healthy dogs by artificially removing a small piece of the skull, which can be done without causing any serious injury. In animals thus operated upon, the same changes of volume can be seen to occur in the brain, and closer observation shows that the variations are due to contraction or expansion of the blood-vessels.

These investigations demonstrate that one of the physiological conditions of increased mental action is an increased supply of blood, which is produced principally by a dilatation of the cerebral blood-vessels, accompanied by a contraction of the blood-vessels of other parts of the body. The measurable volume of the arm is thus partly a signal of the condition of the mind we can not measure, as affirmed in the early part of this article.

In connection with the new tendencies of psychology and physiology, such investigations as we have just described acquire a peculiar significance. The progress of knowledge has so enlarged the domains of both psychology and physiology, that they now overlap. The fields of investigation held in common form the bourn of "physiological psychology," as it is termed by the Germans, who are ever ready with a new name. Now, the mind derives its material through the senses. The sensations arise from physical causes. The final results of mental performances are various actions of the body, physical events such as motion and speech. Physics, therefore, are the alpha and omega of our mental history. Concerning what occurs between the physical cause of sensation and the physical result of mental action, two extreme opinions stand opposed. On the one hand, mind is defined as a succession of purely physical phenomena; on the other, as a supernatural and immortal power.

Hitherto psychologists have usually studied very little besides what we might call the natural history of the mind. Just as the ornithologist may study the habits of a bird, its mode of hopping, flying, feed-

ing, singing, and so forth, and make himself thoroughly familiar with its natural history, without learning anything of its anatomy, the laws of muscular contraction or digestion, so also the philosopher may investigate the actions of the mind, the succession and relations of ideas, or may formulate the principles of logic, in entire ignorance of the processes which occur in the brain. The conclusions in both cases may be perfectly accurate, but they do not concern the more hidden and less accessible factors.

It is important to recognize the relation of psychology to the physiology of the brain, and to relegate both to their proper places. In reality they are only the different sides of one study—and the best distinction of psychology is its success in arranging and classifying the psychic phenomena, whose relation to the physical basis of mind is to be determined. Although psychology is usually regarded as a department of philosophy, it is certainly more completely a natural science, since it deals with natural events, which are learned by direct observation, and which we coördinate by our reason. The slow but unmistakable gravitation of psychology toward physiology does not forecast, it seems to me, the demise of the former, but indicates rather that psychologists, having now gathered and arranged a great mass of data concerning the mind, are making an inevitable step in progress in seeking deeper than ever before for explanations. During the new phase, into which psychology has apparently entered, the principal problems will probably concern the relation of mind to the substratum of matter in which it displays itself. The most important steps which we can hope to take at present must, as far as we can judge, be taken in the field of physiological psychology, the essential purpose of which is to discover the exact nature of the dependence of the psychic phenomena on the physiological and anatomical properties of the body. It is precisely in this direction that Professor Mosso has made an important advance.

Mind appears to us as an image, dimly seen through the clouds of physical facts which encompass it. Some assert it to be merely a mirage, or, at most, an accidental shape into which physical facts have compiled themselves. Others believe that mind is a thing of its own kind. When the sunlight of discovery shall dispel the mists of the unknown, that conceal the true nature of the mind, then that image, now so dim, will become distinct, and its real character evident. That such a result is attainable is the belief, without which many laborious investigations would become purposeless.

GOETHE'S FARBENLEHRE.—(THEORY OF COLORS.*)

By Professor JOHN TYNDALL, F. R. S.

II.

ONE hole Goethe did find in Newton's armor, through which he incessantly worried the Englishman with his lance. Newton had committed himself to the doctrine that refraction without color was impossible. He therefore thought that the object-glasses of telescopes must for ever remain imperfect, achromatism and refraction being incompatible. This inference was proved by Dollond to be wrong.† With the same mean refraction, flint-glass produces a longer and richer spectrum than crown-glass. By diminishing the refracting angle of the flint-glass prism, its spectrum may be made equal in length to that of the crown-glass. Causing two such prisms to refract in opposite directions, the colors may be neutralized, while a considerable residue of refraction continues in favor of the crown. Similar combinations are possible in the case of lenses; and hence, as Dollond showed, the possibility of producing a compound achromatic lens. Here, as elsewhere, Goethe proves himself master of the experimental conditions. It is the power of interpretation that he lacks. He flaunts this error regarding achromatism incessantly in the face of Newton and his followers. But the error, which was a real one, leaves Newton's theory of colors perfectly unimpaired.

Newton's account of his first experiment with the prism is for ever memorable. "To perform my late promise to you," he writes to Oldenburg, "I shall without further ceremony acquaint you that in the year 1666 (at which time I applied myself to the grinding of optick-glasses of other figures than spherical) I procured me a triangular glass prism, to try therewith the celebrated phenomena of colors. And in order thereto, having darkened my chamber, and made a small hole in my window-shuts, to let in a convenient quantity of the sun's light, I placed my prism at its entrance, that it might be thereby refracted to the opposite wall. It was at first a very pleasing divertisement, to view the vivid and intense colors produced thereby; but after a while applying myself to consider them more circumspectly, I became surprised to see them in an oblong form, which, according to the received laws of refractions, I expected should have been circular. They were terminated at the sides with straight lines, but at the ends the decay of light was so gradual that it was difficult to determine justly what was their figure, yet they seemed semicircular.

* A discourse delivered in the Royal Institution of Great Britain, on Friday evening, March 19, 1880.

† Dollond was the son of a Huguenot. Up to 1752 he was a silk-weaver at Spitalfields; he afterward became an optician.

"Comparing the length of this colored *spectrum* with its breadth, I found it about five times greater; a disproportion so extravagant that it excited me to a more than ordinary curiosity of examining from whence it might proceed." This curiosity Newton gratified by instituting a series of experimental questions, the answers to which left no doubt upon his mind that the elongation of his spectrum was due to the fact "that *light* is not similar or homogeneal, but consists of *difform rays, some of which are more refrangible than others;* so that, without any difference in their incidence on the same medium, some shall be more *refracted* than others; and therefore that, according to their *particular degrees of refrangibility*, they were transmitted through the prism to divers parts of the opposite wall. When," continues Newton, "I understood this, I left off my aforesaid glass-works; for I saw that the perfection of telescopes was hitherto limited, not so much for want of glasses truly figured according to the prescriptions of optick authors, as because that *light* itself is an heterogeneous mixture of *differently refrangible rays;* so that were a glass so exactly figured as to collect any one sort of rays into one point, it could not collect those also into the same point, which, having the same incidence upon the same medium, are apt to suffer a different refraction."

Goethe harped on this string without cessation. "The Newtonian doctrine," he says, "was really dead the moment achromatism was discovered. Gifted men, our own Klügel, for example, felt this, but expressed themselves in an undecided way. On the other hand, the school which had been long accustomed to support, patch up, and glue their intellects to the views of Newton, had surgeons at hand to embalm the corpse, so that even after death, in the manner of the Egyptians, it should preside at the banquets of the natural philosophers."

In dealing with the chromatic aberration of lenses, Goethe proves himself to be less heedful than usual as an experimenter. With the clearest perception of principles, Newton had taken two pieces of cardboard, the one colored a deep red, the other a deep blue. Around those cards he had wound fine black silk, so that the silk formed a series of separate fine dark lines upon the two colored surfaces. He might have drawn black lines over the red and blue, but the silk lines were finer than any that he could draw. Illuminating both surfaces, he placed a lens so as to cast an image of the surfaces upon a white screen. The result was that, when the dark lines were sharply defined upon the red, they were undefined upon the blue; and that, when, by moving the screen, they were rendered distinct upon the blue, they were indistinct upon the red. A distance of an inch and a half separated the focus of red rays from the focus of blue rays, the latter being nearer to the lens than the former. Goethe appears to have attempted a repetition of this experiment; at all events he flatly contradicts Newton, ascribing his result not to the testimony of his bodily eyes, but to that of the prejudiced eyes of his mind. Goethe always saw

the dark lines best defined upon the brighter color. It was to him purely a matter of contrast, and not of different refrangibility. He argues caustically that Newton proves too much; for, were he correct, not only would a dioptric telescope be impossible, but, presented to our naked eyes, differently colored objects must appear utterly confusing. Let a house, he says, be supposed to stand in full sunshine; let the roof-tiles be red, the walls yellow, with blue curtains behind the open windows, while a lady with a violet dress steps out of the door. Let us look at the whole from a point in front of the house. The tiles we will suppose appear distinct, but on turning to the lady we should find both the form and the folds of her dress undefined. We must move forward to see her distinctly, and then the red tiles would appear nebulous. And so with regard to the other objects, we must move to and fro in order to see them clearly if Newton's pretended second experiment were correct. Goethe seems to have forgotten that the human eye is not a rigid lens, and that it is able to adjust itself promptly and without difficulty to differences of distance enormously greater than that due to the different refrangibility of the differently colored rays.

Newton's theory of colors, it may be remarked, is really less a "theory" than a direct presentation of facts. Given the accepted definition of refraction, it is a matter of fact, and not of theoretic inference, that white light is not "homogeneal," but composed of differently refrangible rays. The demonstration is ocular and complete. Having palpably decomposed the white light into its constituent colors, Newton recompounded these colors to white light. Both the analysis and the synthesis are matters of fact. The so-called "theory of light and colors" is in this respect very different from the corpuscular theory of light. Newton's explanation of color stands where it is, whether we accept the corpuscular or the undulatory theory; and it stands because it is at bottom not a theory but a body of fact, to which theory must bow or disappear. Newton himself pointed out that his views of colors were entirely independent of his belief in the "corporiety" of light.

After refraction-colors Goethe turns to those produced by diffraction; and, as far as the phenomena are concerned, he deals very exhaustively with the colors of thin plates. He studies the colors of Newton's rings both by reflected and transmitted light. He states the conditions under which this class of colors is produced, and illustrates the conditions by special cases. He presses together flat surfaces of glass, observes the flaws in crystals and in ice, refers to the iridescences of oil on water, to those of soap-bubbles, and to the varying colors of tempered steel. He is always rich in facts. But, when he comes to deal with physical theory, the poverty and confusion of his otherwise transcendent mind become conspicuous. His turbid media entangle him everywhere, leading him captive and committing him to almost

incredible delusions. The colors of tempered steel, he says, and kindred phenomena, may perhaps be *quite conveniently deduced* from the action of turbid media. Polished steel powerfully reflects light, and the coloring produced by heating may be regarded as a feeble turbidity, which, acted upon by the polished surface behind, produces a bright yellow. As the turbidity augments, this color becomes dense, until finally it exhibits an intense ruby-red. Supposing this color to reach its greatest proximity to darkness, the turbidity continuing to augment as before, we shall have behind the turbid medium a dark background, which appears first violet, then dark blue, and finally light blue, thus completing the cycle of the phenomena. The mind that could offer such an explanation as this must be qualitatively different from that of the natural philosopher.

The words "quite conveniently deduced," which I have italicized in the last paragraph, are also used by Goethe in another place. When the results of his experiments on prismatic colors had to be condensed into one commanding inference, he enunciated it thus: "Und so lassen sich die Farben bei Gelegenheit der Refraction aus der Lehre von den trüben Mitteln gar bequem ableiten." This is the crown of his edifice, and it seems a feeble ending to so much preparation. Kingsley once suggested to Lewes that Goethe might have had a vague feeling that his conclusions were not sound, and that he felt the jealousy incident to imperfect conviction. The ring of conscious demonstration, as it is understood by the man of science, is hardly to be found in the words "gar bequem ableiten." They fall flaccid upon the ear in comparison with the mind-compelling Q. E. D. of Newton.

Throughout the first 350 pages of his work, wherein he develops and expounds his own theory, Goethe restrains himself with due dignity. Here and there, there is a rumble of discontent against Newton, but there is no sustained ill-temper or denunciation. After, however, having unfolded his own views, he comes to what he calls the "unmasking of the theory of Newton." Here Goethe deliberately forsakes the path of calm, objective research, and delivers himself over to the guidance of his emotions. He immediately accuses Newton of misusing, as an advocate, his method of exposition. He goes over the propositions in Newton's "Optics" one by one, and makes even the individual words of the propositions the objects of criticism. He passes on to Newton's experimental proofs, invoking, as he does so, the complete attention of his readers, if they would be freed to all eternity from the slavery of a doctrine which has imposed upon the world for a hundred years. It might be thought that Goethe had given himself but little trouble to understand the theorems of Newton and the experiments on which they were based. But it would be unjust to charge the poet with any want of diligence in this respect. He repeated Newton's experiments, and in almost every case obtained his

results. But he complained of their incompleteness and lack of logical force. What appears to us as the very perfection of Newton's art, and absolutely essential to the purity of the experiments, was regarded by Goethe as needless complication and mere torturing of the light. He spared no pains in making himself master of Newton's data, but he lacked the power of penetrating either their particular significance, or of estimating the force and value of experimental evidence generally.

He will not, he says, shock his readers at the outset by the utterance of a paradox, but he can not withhold the assertion that by experiment nothing can really be proved. Phenomena may be observed and classified; experiments may be accurately executed, and made thus to represent a certain circle of human knowledge; but deductions must be drawn by every man for himself. Opinions of things belong to the individual, and we know only too well that conviction does not depend upon insight, but upon will—that man can only assimilate that which is in accordance with his nature, and to which he can yield assent. In knowledge, as in action, says Goethe, prejudice decides all, and prejudice, as its name indicates, is judgment prior to investigation. It is an affirmation or a negation of what corresponds, or is opposed to our own nature. It is the cheerful activity of our living being in its pursuit of truth or of falsehood, as the case may be —of all, in short, with which we feel ourselves to be in harmony.

There can be no doubt that Goethe, in thus philosophizing, dipped his bucket into the well of profound self-knowledge. He was obviously stung to the quick by the neglect of the physicists. He had been the idol of the world, and, accustomed as he was to the incense of praise, he felt sorely that any class of men should treat what he thought important with indifference or contempt. He had, it must be admitted, some ground for skepticism as to the rectitude of scientific judgments, seeing that his researches on morphology met at first no response, though they were afterward lauded by scientific men. His anger against Newton incorporates itself in sharp and bitter sarcasm. Through the whole of Newton's experiments, he says, there runs a display of pedantic accuracy, but how the matter really stands, with Newton's gift of observation, and with his experimental aptitudes, every man possessing eyes and senses may make himself aware. It may, he says, be boldly asked, Where can the man be found, possessing the extraordinary gifts of Newton, who would suffer himself to be deluded by such a *hocus pocus* if he had not in the first instance willfully deceived himself? Only those who know the strength of self-deception, and the extent to which it sometimes trenches on dishonesty, are in a condition to explain the conduct of Newton, and of Newton's school. "To support his unnatural theory," he continues, "Newton heaps experiment on experiment, fiction upon fiction, seeking to dazzle where he can not convince."

It may be that Goethe is correct in affirming that the will and preju-

dice of the individual are all-influential. We must, however, add the qualifying words, "as far as the individual is concerned." For in science there exists, apart from the individual, objective truth; and the fate of Goethe's own theory, though commended to us by so great a name, illustrates how, in the progress of humanity, the individual, if he err, is left stranded and forgotten—truth, independent of the individual, being more and more grafted on to that tree of knowledge which is the property of the human race.

The imagined ruin of Newton's theory did not satisfy Goethe's desire for completeness. He would explore the ground of Newton's error, and show how it was that one so highly gifted could employ his gifts for the enunciation and diffusion of such unmitigated nonsense. It was impossible to solve the riddle on purely intellectual grounds. Scientific enigmas, he says, are often only capable of ethical solution, and with this maxim in his mind he applies himself, in the second volume of the "Farbenlehre," to the examination of "Newton's Persönlichkeit." He seeks to connect him with, or rather to detach him from, the general character of the English nation—that sturdy and competent race which prizes above all things the freedom of individual action. Newton was born in a storm-tossed time—none, indeed, more pregnant in the history of the world. He was a year old when Charles I. was beheaded, and he lived to see the First George upon the throne. The shock of parties was in his ears, changes of ministries, parliaments, and armies were occurring before his eyes while the throne itself, instead of passing on by inheritance, was taken possession of by a stranger. What, asks Goethe, are we to think of a man who could put aside the claims, seductions, and passions incident to such a time, for the purpose of tranquilly following out his bias as an investigator?

So singular a character arrests the poet's attention. He had laid down his theory of colors; he must add to it a theory of Newton. The great German is here at home, and Newton could probably no more have gone into these disquisitions regarding character than Goethe could have developed the physical theories of Newton. He prefaces his sketch of his rival's character by reflections and considerations regarding character in general. Every living thing, down to the worm that wriggles when trod upon, has a character of its own. In this sense even the weak and cowardly have characters, for they will give up the honor and fame which most men prize highest, so that they may vegetate in safety and comfort. But the word character is usually applied to the case of an individual with great qualities, who pursues his object undeviatingly, and without permitting either difficulty or danger to deflect him from his course.

"Although here, as in other cases," says Goethe, "it is the exuberant (Ueberschwängliche) that impresses the imagination, it must not be imagined that this attribute has anything to do with moral feeling.

The main foundation of the moral law is a *good* will,* which, in accordance with its own nature, is anxious only for the right. The main foundation of character is a *strong* will, without reference to right or wrong, good or bad, truth or error. It is that quality which every party prizes in its members. A good will cherishes freedom, it has reference to the inner man and to ethical aims. The strong will belongs to nature and has reference to the outer world—to action. And, inasmuch as the strong will in this world is swayed and limited by the conditions of life, it may almost be assumed as certain that it is only by accident that the exercise of a strong will and of moral rectitude find themselves in harmony with each other." In determining Newton's position in the series of human characters, Goethe helps himself to images borrowed from the physical cohesion of matter. Thus, he says, we have strong, firm, compact, elastic, flexible, rigid or obstinate, and viscous characters. Newton's character he places under the head of rigid or obstinate, and his theory of colors Goethe pronounces to be a petrified *aperçu*.

Newton's assertion of his theory and his unwavering adherence to it to the end of his life Goethe ascribes straight off to moral obliquity on Newton's part. In the heat of our discussion, he says, we have even ascribed to him a certain dishonesty. Man, he says, is subject to error, but when errors form a series, which is followed pertinaciously, the erring individual becomes false to himself and to others. Nevertheless, reason and conscience will not yield their rights. We may belie them, but they are not deceived. It is not too much to say that, the more moral and rational a man is, the greater will be his tendency to lie when he falls into error, and the vaster will be that error when he makes up his mind to persist in it.

This is all intended to throw light upon Newton, but, when Goethe passes from Newton himself to his followers, the small amount of reserve which he exhibited when dealing with the master entirely disappears. He mocks their blunders as having not even the merit of originality. He heaps scorn on Newton's imitators. The expression of even a truth, he says, loses grace in repetition, while the repetition of a blunder is impertinent and ridiculous. To liberate one's self from an error is difficult, sometimes indeed impossible for even the strongest and most gifted minds. But to take up the error of another, and persist in it with stiff-necked obstinacy, is a proof of poor qualities. The obstinacy of a man of originality when he errs may make us angry, but the stupidity of the copyist irritates and renders us miserable. And, if in our strife with Newton we have sometimes passed the bounds of moderation, the whole blame is to be laid upon the school of which Newton was the head, whose incompetence is proportional to its arrogance, whose laziness is proportional to its self-sufficiency, and

* I have rendered Goethe's "gute Wille" by *good* will; his "Wollen," which he contrasts with "Wille," I have rendered by *strong* will.

whose virulence and love of persecution hold each other in perfect equilibrium.

There is a great deal more invective of this kind; but you will probably, and not without sadness, consider this enough. Invective may be a sharp weapon, but over-use blunts its edge. Even when the denunciation is just and true, it is an error of art to indulge in it too long. We not only incur the risk of becoming vapid, but of actually inverting the force of reprobation which we seek to rouse, and of bringing it back by recoil upon ourselves. At suitable intervals, separated from each other by periods of dignified reserve, invective may become a real power of the tongue or pen. But indulged in constantly it degenerates into scolding, and then, instead of being regarded as a proof of strength, it is accepted, even in the case of a Goethe, as an evidence of weakness and lack of self-control.

If it were possible to receive upon a mirror Goethe's ethical image of Newton and to reflect it back upon its author, then, as regards vehement persistence in wrong thinking, the image would accurately coincide with Goethe himself. It may be said that we can only solve the character of another by the observation of our own. This is true; but in the portraiture of character we are not at liberty to mix together subject and object as Goethe mixed himself with Newton. So much for the purely ethical picture. On the scientific side something more is to be said. I do not know whether psychologists have sufficiently taken into account that, as regards intellectual endowment, vast wealth may coexist with extreme poverty. I do not mean to give utterance here to the truism that the field of culture is so large that the most gifted can master only a portion of it. This would be the case supposing the individual at starting to be, as regards natural capacity and potentiality, rounded like a sphere. Something more radical is here referred to. There are individuals who at starting are not spheres, but hemispheres; or, at least, spheres with a segment sliced away—full-orbed on one side, but flat upon the other. Such incompleteness of the mental organization no education can repair. Now, the field of science is sufficiently large, and its studies sufficiently varied, to bring to light in the same individual antitheses of endowment like that here indicated.

So far as science is a work of ordering and classification, so far as it consists in the discovery of analogies and resemblances which escape the common eye—of the fundamental identity which often exists among apparently diverse and unrelated things—so far, in short, as it is observational, descriptive, and imaginative, Goethe, had he chosen to make his culture exclusively scientific, might have been without a master, perhaps even without a rival. The instincts and capacities of the poet lend themselves freely to the natural history sciences. But, when we have to deal with stringently physical and mechanical conceptions, such instincts and capacities are out of place. It was in this

region of mechanical conceptions that Goethe failed. It was on this side that his sphere of capacity was sliced away. He probably was not the only great man who possessed a spirit thus antithetically mixed. Aristotle himself was a mighty classifier, but not a stringent physical reasoner. And, had Newton attempted to produce a "Faust," the poverty of his intellect on the poetic and dramatic side might have been rendered equally manifest. But here, if not always, Newton abstained from attempting that for which he had no capacity, while the exuberance of Goethe's nature caused him to undertake a task for which he had neither ordination nor vocation, and in the attempted execution of which his deficiencies became revealed.

One task among many—one defeat amid a hundred triumphs. But any recognition on my part of Goethe's achievements in other realms of intellectual action would, I fear, be regarded as impertinent. You remember the story of the First Napoleon when the Austrian plenipotentiary, in arranging a treaty of peace, began by formally recognizing the French Republic. "Efface that," said the First Consul; "the French Republic is like the sun; he is blind who fails to recognize it." And were I to speak of recognizing Goethe's merits, my effacement would be equally well deserved. "Goethe's life," says Carlyle, "if we examine it, is well represented in that emblem of a solar day. Beautifully rose our summer sun, gorgeous in the red, fervid east, scattering the specters and sickly damps, of both of which there were enough to scatter; strong, benignant in his noonday clearness, walking triumphant through the upper realms—and now mark also how he sets! 'So stirbt ein Held'; so dies a hero!"

Two grander illustrations of the aphorism "To err is human" can hardly be pointed out in history than Newton and Goethe. For Newton went astray not only as regards the question of achromatism, but also as regards a vastly larger question touching the nature of light. But though as errors they fall into the same category, the mistake of Newton was qualitatively different from that of Goethe. Newton erred in adopting a wrong mechanical conception in his theory of light, but in doing so he never for a moment quitted the ground of strict scientific method. Goethe erred in seeking to ingraft in his "Farbenlehre" methods altogether foreign to physics on to the treatment of a purely physical theme.

We frequently hear protests made against the cold mechanical mode of dealing with æsthetic phenomena employed by scientific men. The dissection by Newton of the light to which the world owes all its visible beauty and splendor seemed to Goethe a desecration. We find, even in our own day, the endeavor of Helmholtz to arrive at the principles of harmony and discord in music resented as an intrusion of the scientific intellect into a region which ought to be sacred to the human heart. But all this opposition and antagonism has for its essential cause the incompleteness of those with whom it originates. The feel-

ings and aims with which Newton and Goethe respectively approached Nature were radically different, but they had an equal warrant in the constitution of man. As regards our tastes and tendencies, our pleasures and pains, physical and mental, our action and passion, our sorrows, sympathies, and joys, we are the heirs of all the ages that preceded us; and, of the human nature thus handed down, poetry is an element just as much as science. The emotions of man are older than his understanding, and the poet who brightens, purifies, and exalts these emotions, may claim a position in the world at least as high and as well-assured as that of the man of science. They minister to different but to equally permanent needs of human nature; and the incompleteness of which I complain consists in the endeavor on the part of either to exclude the other. There is no fear that the man of science can ever destroy the glory of the lilies of the field; there is no hope that the poet can ever successfully contend against our right to examine, in accordance with scientific method, the agent to which the lily owes its glory. There is no necessary encroachment of the one field upon the other. Nature embraces them both, and man, when he is complete, will exhibit as large a toleration.

MY FIRE.

By Professor F. W. CLARKE.

WITHIN my grate a cheerful blaze
Lights up the room with ruddy rays,
That blunt the winter's sharpest stings
With bygone summer's offerings.
I sit and watch the leaping flame,
In wonder whence its beauty came;
And trace it back to days of old,
When Earth's hard crust was scarcely cold,
And tropic trees in arctic zones
Taught the north-wind those subtile tones,
Which, now and then, its weary blast
Seems to regather from the past,
To murmur in a mystic song
The secret-keeping pines among.
And, as I gaze, I somehow see
Strange things that long have ceased to be:
The sooty carbon seems to glow
With memories of long ago,
And in the flickering lines of gold
The story of its past is told.

Ages ago, when Earth was young,
And all her beauties yet unsung—
Save in the songs that Nature weaves
Into the texture of the leaves,
Or teaches to the insect swarms
That fill the light with darting forms—
A meteor, like some silly moth,
To meet destruction nothing loath,
Drawn by a force it could not shun,
Broke from its circles round the Sun,
And in a flashing spiral flight
Shot to the central source of light.
New fuel fed the solar flame;
New sunbeams into being came;
And these, unconscious of their birth,
Sought speedily the whirling Earth.

In that far-off, mysterious day
The undeveloped planet lay
Afloat in space, a different thing
From that which bears us on its wing.
Forgotten rivers downward ran
From mountains never seen by man,
To oceans, long since dried away,
Whose beds are continents to-day.
And overhead the heavens bent
Not wholly like our firmament.
Some stars, perchance, that now are cold,
In their deserted orbits rolled;
And others shone more brightly then
Than since abashed by gaze of men.
The very Sun intenser glowed
As on the heavenly way he strode,
And sent to space the fiercer heat
Of fiery youth and vigor sweet.

Through vapors dense the sunbeams fell,
And worked in passing many a spell
On ancient rocks and flowing streams,
And decked with unaccustomed gleams
The wings of insects proud to be
The wearers of such livery.
Then on through forests where the breeze
Found giant ferns grown into trees,
That in their waving branches held
The wealth of summer undispelled.

Strange flowers turned bright faces up
To catch the light in many a cup,
And all of nature gladly sought
The blessings by the sunbeams wrought.
But these fair rays whose deeds I sing
Staid nowhere long for anything ;
Leaping from rock, and leaf, and tree,
From stream and pool with equal glee,
Until, half buried in the ground,
A freshly fallen seed they found.
And here they halted ; here at last
A welcome duty held them fast.

As day by day the sunbeams fell,
A tiny leaflet burst its shell ;
And soon a stem of tender green
Was thrust above the earthy screen.
Daily it drank the air and dew ;
Daily the sunlight warmed it through ;
Up to a mighty tree it grew.
A tower of fronded foliage high
Above the forest sought the sky ;
Whose sturdy stem, erect, defied
Tempest or flood with haughty pride,
And for a century bravely stood
The monarch of the solitude.

But Time, who conquers all things, saw
This perfect tree without a flaw ;
And sent an insect, weak and small,
To bring about its certain fall.
Gnawed at the root, its strength decayed ;
The forest giant bent and swayed,
And with a shuddering crash it fell
From the high place it loved so well.
Buried in slime, and ooze, and clay,
The perished king forgotten lay.

The Ages, with resistless tread,
Marched slowly on above the dead ;
And where the tree had grandly grown
They piled a thousand feet of stone.
A royal tomb, with royal state,
Was token of the monarch's fate :
Surely the future has for us
No worthier sarcophagus.

At last came Man, with eager brain,
To ransack Earth in search of gain;
And where a brook had cleft apart
The rocks to reach a mountain's heart,
Deep in the chasm he could trace
An ancient forest's burial-place.
In sheets of coal the eye could mark
The very texture of the bark;
And see, with every tender vein
Still sharply outlined, clear and plain,
Leaves that had wooed the morning sun
When Time itself was scarce begun,
And turned to stone the giant stem
That wore the leafy diadem.

Brightly my fire of coal may burn—
Backward my thoughts, resistless, turn.
With keen imagination's eye
I see the Ages passing by:
I see the meteor's headlong flight;
A planet's death; the birth of light;
The ancient world, unlike our own;
The mighty forest turned to stone;
And, scene by scene, before my eyes,
The whole long vanished past arise.
And from my grate I feel the glow
Of sunbeams fallen long ago,
Stored up by Nature's magic art
Within a tree's untainted heart,
To sleep a myriad ages long,
And wake the subject of a song.

A VINDICATION OF SCIENTIFIC ETHICS.*

By WILLIAM D. LE SUEUR, B. A.

MR. SPENCER, in his "Data of Ethics," has not written a popular treatise on morals, nor has he appealed to any lower tribunal than the highest intelligence and the maturest judgment of his generation. The more I think of his book, the more it seems to me a sign that shall be spoken against, but a sign, at the same time, in which, or by which, great victories will be won for the human race.

* This able article first appeared in "The Canadian Monthly," under the title of of "Mr. Spencer and His Critics."

I am far from saying that it tells us everything we might wish to know in regard to the springs of conduct, or the special sources of moral energy; but I contend that it tells us much that is of supreme importance, and that anything we may require to add to the statements it contains will not be found in conflict with the writer's main positions.

Mr. Spencer, it must be understood, undertakes to trace for us the evolution of morality as an objective process. Morality, like everything else, must have a history. What is that history? This is the question to which Mr. Spencer addresses himself. If we can trace the development of morality in the past, we shall be better able to understand its characteristics in the present, and its probable course in the future. Mr. Spencer says truly that morality is a certain aspect of *conduct* in general; it is, as he holds, *developed* conduct; and, in order that we may understand what conduct is, he asks us to examine it in its earliest manifestations, and to follow it through the ages, as it gains in definiteness, in complexity, in range, and in the importance of its reactions upon consciousness. This is a view, the legitimacy of which it seems impossible to dispute. When our attention is arrested by any structure in nature, we very properly ask: "How has it come to be what it is? Did it spring into existence at once, in the form under which we behold it now, or was it shaped by slow degrees? If the latter, what were the stages through which it successively passed?" Do not tell us that the same questions can not profitably be asked in regard to morality until the questions have been fairly put and answered according to the best obtainable knowledge.

The great objection hitherto made to the scientific study of history, or of any moral subject, has been that all calculations based upon general laws of growth or progress are liable at any moment to be thrown into confusion by the appearance upon the scene of forces or of influences of a wholly exceptional character. Thus the birth of some man of transcendent abilities may alter, it is said, the whole course of a nation's history. The answer to this objection is twofold: first, that the great man or hero is himself a product of antecedent conditions, and is born into a society more or less fitted to feel and submit to his influence; secondly, that the effects wrought by exceptional characters are but exceptional, and that the great stream of human development follows its course but little affected by accidents here or there. Mr. Spencer, therefore, and those who think with him, may, without in the least compromising their system, make large admissions as to the influence of certain special agencies. They do not necessarily blind themselves to the course of history in the ordinary sense of the word, because they make a special study of the development of conduct. The line of observation and argument pursued in the "Data of Ethics" is hopelessly antagonistic only to that form of supernaturalism which disbelieves totally in evolution, preferring to regard human history as

the theatre of forces having no relation to preceding conditions, and acting consequently as simple disturbers of the natural equilibrium of society. The adherents of this school must only fight the development theory as best they may. The battle is engaged, however, along the whole line, and, to defeat evolution, you must defeat it not in ethics only, but in biology and physics as well. As long as the two latter divisions hold their ground, be sure that any victory over the first can be but momentary.

It is obvious that the method pursued by Mr. Spencer must give rise to many misapprehensions. The first thought that suggests itself to even an attentive and earnest reader is, that he has left out of sight, and is prevented by his principles from doing justice to, a number of very important considerations. Our individual consciousness tells us nothing of the dependence of present modes of conduct upon past; but it tells us much of the special motives which influence us from moment to moment. So a wave of the sea, if we could imagine it conscious, might know much of the pressure of adjacent waves and its own adjustments of form in consequence of that pressure, but might know nothing of ocean-currents or the attraction of sun and moon. We feel the influence of some potent personality, but think little of the causes that have fitted us to do so; yet, to be able to trace and understand those causes, would give us a far more comprehensive theory of our moral nature than to be able to analyze and measure with the utmost accuracy the special personal influence by which we are so strongly affected. In a word, what may be called the accidents of our life fill an altogether larger space in consciousness than the general laws, in virtue of which we are substantially what we are. Mr. Spencer has undertaken to trace those general laws, leaving accidents out of sight as much as possible; and, naturally, consciousness protests. If, however, we only call to mind, and impress upon ourselves, what it is that Mr. Spencer attempts, we shall recall many of our criticisms, and find it better to listen attentively to what he has to say.

Again, with every action there goes a certain accompaniment of individual feeling. We have a sense of its voluntariness, and a consequent sense of responsibility. To us, each action stands and is seen in relation to the sum of our own individual actions, and the proportion which it bears to that sum is very different from the proportion it bears to the whole sum of action in general. It is easy, therefore, to conceive how different the subjective view of action must be from the objective, and how far a history of action such as Mr. Spencer undertakes to write must be from such an account as we might gather from the dicta of consciousness. But, if our individual lives are but links in one great chain of life, which we have learned in these latter days to extend to the lowest forms of the animate creation, can the individual consciousness, however bright and penetrating we may suppose it, be trusted in its affirmations regarding the genesis of action and the

development of moral feeling? What can mere consciousness—apart from knowledge derived from external sources—tell us of our bodily constitution and development? It is occupied almost solely with sensations of pleasure and pain; it knows what are proximate causes of one or the other; but what the laws are that rule the human organization it is wholly ignorant. We have absolutely no consciousness of the nature of digestion or respiration; we only know in a rough way what creates disturbances in one region or the other, and what promotes comfort. Is it likely that we shall know any better from a simple questioning of our individual consciousness how our actions are produced, or what is their essential character and true significance? It seems to me that the feelings accompanying moral action are no safer guides to a true understanding of that action than the feelings accompanying digestion are to a true understanding of digestion. The objective method of study, as applied to human conduct, has this great advantage, that, while looking at things from the outside, and grasping the *enchainement* of cause and effect through all past time, it can also take account of the direct revelations of consciousness, so far as these seem to furnish any safe guidance. Mr. Spencer, it may be presumed, knows something personally of the inner life of humanity. He has written this treatise in full view of all that his personal experience has taught him of the motives by which men are swayed, and we must suppose that, in his mind at least, there is no contradiction between his philosophical theories and the teachings of life or the affirmations of consciousness. It is well to bear in mind that philosophers after all are men first and philosophers only afterward.

The adverse criticisms that have been offered upon Mr. Spencer's last work may be said to resolve themselves into two leading objections: first, that he does away with the essential distinction between right and wrong; and, second, that, for regulative purposes, his system is wholly unadapted to human wants. I propose to consider these points separately.

Let us, in the first place, try to understand clearly what Mr. Spencer's view is. Looking at conduct objectively he sees, as we advance from lower to higher forms in nature, an ever-increasing and improving adaptation, first to the preservation of individual life, and next to the preservation of the life of progeny. The lowest creatures in the animal kingdom possess little or no power of self-protection, and are therefore, broadly speaking, wholly at the mercy of their environment. With greater complexity of structure comes greater power of providing for wants and averting dangers; while the interests of the progeny become more and more a care to the parent animals. The time comes, in process of evolution, when the individual acquires the power of choice between opposite courses of action. One sense may prompt to a certain line of action, and another to a different one. Smell, for example, may attract to food, but sight may reveal an enemy of supe-

rior power; or certain mental images, which the sight of offered food, or of the apparatus in which it is placed, calls up, may inspire caution and compel abstinence. Mr. Spencer here shows that the interest of the individual is generally concerned in obeying the higher or more lately-developed sense, instinct, or faculty, in preference to the simpler and more primitive impulse; and this distinction between actions inspired by more far-reaching and those inspired by less far-reaching perceptions he considers as homologous to the distinction which emerges in the human region—and which, as civilization advances, becomes ever more pronounced—between right and wrong. In the one case the individual weighs present gratification against his permanent interests as an individual; in the second he weighs his interests as an individual against those of the social body in which he is included. In either case he does well if he yield to the larger thought—that which summons to self-control, and which promises a continuance and enlargement of his activities. From this point of view the conduct which places a man in harmony with society is simply an extension, a further development, of the conduct which places him in harmony with himself, by subordinating his momentary desires to his permanent interests. In the one case he says: "I have a larger life to consider than that of this moment; I have all my past, the memory of which I would not wish to extinguish; I have all my future, which I am not prepared to sacrifice." In the latter he says: "I have a larger life to consider than that which is made up of my personal pains and pleasures; I have inherited sympathies and acquired attachments; the good will of my fellow-man is much to me, and I feel that, apart from the support and assistance that they render me and apart from the activities I exercise as a member of society, I should be a miserably contracted creature. Shall I therefore in the interests of my narrower self make war upon my larger and better self by pursuing anti-social courses of action?" The argument in both cases is the same; the only difference is that in one case length of life is at stake, and in the other breadth of life; but all higher action, it may be assumed as a principle, tends to life. "Do this and ye shall live"; in these words lies all that the evolution philosophy has to teach on the subject of morals; for they summon to right action, and they point to the reward—LIFE.

I fail to see that under this mode of treatment the distinction between right and wrong is in danger of disappearing. Those possibly who have considered it a pious thing not to know why right is right or why wrong is wrong may resent being told that a *rationale* of the antagonism between the two has been discovered. They may insist that they have hitherto done right and avoided wrong from motives far transcending in elevation any regard for perpetuation or improvement of life, their own or others'; and it would be ungracious, doubtless, to contradict them. But, for all that, as a motive to sway the mass of mankind, the thought that right action tends to life and higher life,

that wrong action tends to lower life and ultimately to extinction of life, should scarcely, one would think, be a sterile or inoperative one. Much would depend, no doubt, upon the mode in which the thought was presented by those who have it in their power to influence public opinion. That the minds of a large portion of the community have been so poisoned by the drugs of a false theology as to be incapable of responding to any teaching based on the pure laws of nature there is only too much reason to believe; but I should refuse to admit as valid against the evolutionist system of morals any argument drawn from their present condition or requirements.

The objections made to Mr. Spencer's explanation of the difference between right and wrong are very similar to those made to the Darwinian theory of the descent of man. In the dispute which raged more violently some years ago than it does now in reference to this question, an angelic character pronounced himself "on the side of the angels," as was but natural. It was thought utterly derogatory to man's dignity to suppose that his ancestry could run back into the brute creation; and so to-day it seems to threaten the stability of all moral distinctions to connect moral actions, by any process of filiation, with actions which, as we understand morality, present no moral character whatever. But just as no theory of man's origin can make him other than he actually is to-day, so no theory of the origin of morality can affect the fact that in the conscience of the modern civilized man there is a great gulf fixed between right and wrong. But, some will say, upon the evolution theory the highest morality is but self-seeking. Be it so, but if myself embraces other selves, if my personality has globed itself out till it includes a large portion of humanity, I can afford to be self-seeking without any falling away from nobility or disinterestedness. When Jesus said, "He that saveth his life shall lose it, and he that loseth his life shall save it," he meant, as we have always understood, that a careful study and pursuit of narrow personal interests would involve the sacrifice of wider and nobler interests; and that, on the other hand, by a surrender of our lower selves, we could rise to higher life. From whichever point we view it, he bids us aim at *life*, and so far he might be accused of prompting to self-seeking; but when we once see how life may be understood, and what it may be made to include, we perceive how pointless is the objection. It is indeed difficult to imagine how any person, except one who had been restrained from evil simply by superstitious fears, could feel himself less bound to do right and avoid wrong because he had been shown that right actions to-day are the lineal descendants of all those actions, conscious and unconscious, by which life has been preserved, and improved in the past, and that wrong actions claim their paternity in whatever in the past has tended to disintegration, degradation, and death. Who would not rather be on the side of the forces of life, in harmony with and aiding the upward movement of nature,

than helping to tear down the good work that the toiling ages have wrought?

Can such a system, however, possess any binding force? Here we find ourselves face to face with the question, whether the evolutionist theory of morals is really adapted to take the place of those regulative systems which Mr. Spencer represents as ready to pass away. One thing is certain: it does not act upon the mind in the same way as systems which appeal to supernatural terrors and hold out a prospect of supernatural rewards. It will not awaken as powerful emotions as theology has in the past awakened; for theology has connected with theologically-right action rewards wholly incommensurate with the merit of such action, and with theologically-wrong action punishments equally incommensurate with its demerit; while the natural theory of morals can only point to the natural results of actions and promote, as best it can, a disposition to respect natural laws. No doubt this is tame work after what we have been accustomed to; but everything grows tame, in a sense, as civilization advances. We no longer torture criminals, nor feast our piety with *autos-da-fe*. We no longer thrash knowledge into school-children; and we are so dead to the necessity of cultivating national spirit that we forbid prize-fighting. Upon every hand, the drastic methods of the past are discredited, for we find, in point of fact, that gentler methods are better. Sangrado no longer depletes our veins of the blood needed for carrying on the processes of life; we keep our blood and let Nature have her way as much as possible. No doubt there is further progress to be made in the same direction; and who shall say that a system of rational rewards and punishments in *this* life, such as the evolution philosophy unfolds, may not be found more efficacious than the monstrous rewards and punishments of the supernatural sphere. Such a system may not inspire death-bed terrors, but neither will it provoke life-long jeerings; and, if once understood theoretically, its gentle—though not always gentle—pressure would rarely be absent from consciousness. The villain, it may be said, will think little of sacrificing his higher social to his lower personal self; and, in his case, therefore, the system would be inoperative. Precisely, and how does Monsieur the villain comport himself now? Does he occupy a front seat at church (something here whispers that sometimes he does, but that is another kind of villain, and there is no use in mixing up matters), and send his children to Sunday-school, and show in every way the great influence which theological instruction has had upon his mind? Or we may ask whether, in the "ages of faith," the villain was an unknown character? History tells us that, when supernatural hopes and fears—above all fears, which are more potent than hopes—were at their highest, precisely then was there most of violence and crime. And, when natural morality finally succeeds to supernatural, it is safe to predict that it will find some heavy arrears of work on hand.

We need not trouble ourselves, then, with considering how the lowest types of humanity will act under the supposed *régime;* what we are concerned with is the effect likely to be produced upon the mass of society. As regards men in general, will natural morality exert a sufficient regulative force? To this question I should be inclined to answer unhesitatingly yes, provided only proper means be taken to bring the new system home to people's understandings. No one will pretend that the theology now in possession exerts all the regulative influence that could be desired. For one thing, it can not make itself believed by large multitudes; and, in the second place, very many of those who do believe it, or who profess to do so, are far from leading edifying lives. Every leading religious denomination has numerous representatives in our jails and penitentiaries, as official documents show; while, if we turn to the records of the insolvency courts, we shall find ample evidence that men can be at once zealous supporters of a church and sadly inexact—to say the least—in money matters. Why do I mention these things? Surely not to cause any one pain, but simply to show how the question stands. Some people argue as if we had *now* a perfect regulative system, which the new opinions are in danger of disturbing. But no; we have a very imperfect regulative system, upon which it is hoped a great improvement may be made. Theologians have, for some time past, been sensible of the shortcomings of the old teaching, for they have been trying to graft upon it the idea of the *naturalness* of the rewards and punishments to be meted out to right- and wrong-doers respectively. We hear now that sinners will not be overtaken by any external penalties, but will be left to the simple and inevitable consequences of their own misconduct. They would not be happy, we are told, in heaven, because their characters are not adapted to that abode of bliss; and, upon the whole, therefore, they are better off on the other side of the great gulf. How all this can be reconciled with the teaching of the Bible, where hell is represented, not as prepared by the sinner for himself, but as prepared by God for the devil and his angels, and heaven, in like manner, as something specially prepared for the righteous, who there enjoy a felicity with which the sufferings of this present time are not worthy to be compared, it is not for me to say. One thing is clear, however, and that is, that such glosses as these are recognitions of and concessions to the principle of development. Heaven, according to this hypothesis, is the developed life of righteousness, and hell the developed life of moral rebellion; but, though theology may dally with this view, it can never do more than dally with it; it can never make it its own, seeing that the text of the Bible so plainly declares the cataclysmal nature of the change which takes place at death. But, if theology has to dally with development, how much better founded, and how much better adapted for acting upon men's minds, must a system be which, from first to

last, assumes development, and which is not checked in its exposition and application of natural laws by any stereotyped creed or text?

In the new system we really have the reconciliation of self-interest and duty, for we see self-interest merging into duty, and we see duty bringing the highest rewards that self-interest could desire. To say that this system will be powerless for regulative purposes is to take a thoroughly unnatural view of human nature. It is to assume some tendency in man to evil, over and above the promptings of the self-protective instinct. Now, this surplusage of evil in human nature I, for one, strenuously deny. Every man comes into the world with a problem to solve, upon the solution of which his whole course in life depends; and that problem is the due balancing of higher and lower instincts in the interest of higher life. To suppress the lower at the bidding of the higher would, as Mr. Spencer shows, be to suppress life itself. This would be casting aside the problem, not solving it. What is important to remember is, that in the lower there is nothing essentially bad, and that the conflict between lower and higher goes on in the region of purely personal desires before it is carried into the region of social relations. An enlightened interpretation of self-interest in regard to personal matters is thus a preparation for enlightened and worthy action in the social region. For example, the man who has strenuously controlled appetite in the interest of health, and who has realized the satisfaction and happiness that come of doing so, will be better fitted to control selfish, in the interest of social, impulses than one who had never learned to control appetite at all. He comes to this higher test fortified by self-conquest, and with an increased sense of the dignity and worth of life—prepared, moreover, to believe that the path of true happiness is an ascending one. Let these truths—for they *are* truths—be believed and taught; let men see the path along which their moral development has lain in the past, and along which it must lie in the future, and we shall have little reason to regret the lures and terrors of the old theology. Either this, or there is some radical flaw in the constitution of things, by reason of which they tend to corruption—a belief which some may hold on theological grounds, but which I venture to say would never commend itself to any unbiased intelligence, irreconcilable, as it is, with the actual existence of good in human nature and human institutions.

The question, however, may be asked whether a naturalistic system of morals will ever excite the enthusiasm, ever create the same intense longing after purity of heart, that has been produced under the influence of the Christian creed. Will it ever show us the "quick-eyed sanctity" which Dr. Newman mentions as a peculiar fruit of the Spirit? Will it ever call forth such a pleading for fuller and higher spiritual life as we find in Charles Wesley's hymn:

"I want a principle within
Of jealous, godly fear,
A sensibility to sin,
A pain to feel it near.

"I want the first approach to feel
Of pride or fond desire,
To catch the wandering of my will,
And quench the kindling fire.

"Quick as the apple of an eye,
O God, my conscience make!
Awake my soul when sin is nigh,
And keep it still awake."

We have in these verses the expression of a passionate desire for conformity to a divine ideal, and the question is, whether we can expect any approach to the same earnestness in pursuit of such excellence or elevation of character as the evolution philosophy indicates as attainable. If allowance be made for the solemnity imparted to the above utterance by the momentous character of Christian beliefs, I see no reason why the moral enthusiasm of humanity should not flow in as full tide through the new channel as through the old. After all, there are but few in every generation who are fired by an intense desire for the highest holiness; and some, it must be remembered, who appear to have very lofty spiritual ambitions, give occasion for the remark that they might better have aimed at humbler achievements. We may, therefore, reasonably hope that, when once it is understood where the hopes of humanity lie, there will be no falling off, to say the least, in the number of those who will strive after nothing short of the highest ideal their minds are capable of conceiving.

In conclusion, let us see what answer can be given to certain specific objections that have been made by able writers to Mr. Spencer's theories on this subject. "The Bystander" thinks that Mr. Spencer's indignation "against Jingoes and their political burglaries; against Fifeshire militiamen who, so long as they are sent to war, are ready to fight on either side; against Christian bishops who lend their sanction to invasion of Afghanistan," is, upon his own principles, unscientific; inasmuch as all these might retort that their actions were the natural product of their particular stage of development. To this I reply that Mr. Spencer's indignation is the measure of his own moral development, and signifies his instinctive recoil from courses of conduct which show the moral sense in a very backward state. Even when we understand how bad actions have come to be performed, and are prepared to make allowances for the perpetrators, we shrink from and denounce them none the less. We surely should allow the philosophers some common human privileges. As to the supposed answer of the burglarious Jingo, the unprejudiced militiaman, and the filibustering bishop, it is in sub-

stance, though not in form, the answer commonly made to moral remonstrance by people who can not understand the grounds of the remonstrance. It matters not whether you come in the name of a scientific morality or of a traditional theology, the man who "will have none of your reproofs" replies promptly, "I see no harm in it." Talk to him of God: he has, *comme tout le monde*, one of his own, who permits that wherein he indulges; and you will have much work to persuade him that your God is of higher authority than his. It will be as tough a task as explaining to him a chapter of "The Data of Ethics."

Professor Calderwood, writing in the January number of the "Contemporary Review," raises the objection that, whereas it is admitted by Mr. Spencer that the words *good* and *bad* are most emphatically applied to those deeds by which men affect one another, this ought not to be so, upon Mr. Spencer's own principles: on the contrary, "no ethical judgments should be so direct, unhesitating, or emphatic as those which pronounce upon the actions contributing to personal satisfaction." The answer to this is simple enough. The historical antecedents or the remote types of moral actions are not themselves necessarily moral. Purposive action in the lower animals is not moral, though it may be said to be a preparation for morality. We pronounce our most emphatic judgments upon those acts by which men affect one another, because in them we see most conspicuously the conflict of higher and lower impulses, and because members of society must have an especial interest in what men do as *members of society*. Every right action done adds to the security and happiness of life, every wrong action implies some diminution of happiness, and seems to threaten the general welfare. The whole of morality is based upon the fact that "there is a lower and a higher"; and wherever the two come plainly into conflict our feelings are more or less strongly engaged. Thus, if we see a man struggling with intemperance and enduring keen suffering in the attempt to conquer the vice, we commend him—even though he may have no wife and children to excite our interest—as much as if we saw him performing, at great cost to himself, an act of social justice. And why? Because we feel so deeply that the struggle is one in the interest of higher, fuller life and happiness.

Professor Calderwood appears to think that he raises a serious difficulty when he asks, "How comes it to pass that actions most commonly and most emphatically commended are actions which most need to be enforced?" I observe that a recent critic* of Professor Calderwood's work on "The Relations of Mind and Brain," while giving the author credit for general intelligence, says that upon occasions he is positively "obtuse." I should certainly be inclined to say that he was in one of his "obtuse" moods when he put the above question. We commend certain actions more than others because the motives that

* London "Spectator," March 6, 1880.

prompt them are higher, because they imply a more distinct step in moral evolution, because the interest of the community is more concerned in their performance. Now, the Professor wants to know why such actions "most need to be enforced." The first thing to say in answer is that such actions are not commonly "enforced" at all. The acts we praise most highly are acts of patriotism, of eminent public spirit, of devotion to duty under trying circumstances. The acts we "enforce" are acts which, when done, we do not so highly praise, such as simple fulfillment of contract, and the performance of ordinary civic duties. It is possible, however, that Professor Calderwood, when he uses the word "enforced," does not mean legal enforcement, but merely the pressure of public opinion. His question would then be in substance, How is it that the actions which we most commend are those which most need to be commended? But he might as well ask how it is that the actions we most *condemn* are those which most need to be condemned; why the actions we laugh at are those that especially call for ridicule; and so on, through a whole series of ineptitudes. Why certain actions are especially praised I have explained above, and it is manifest, from the nature of the actions referred to, that this social approval must powerfully reënforce the motives which prompt to such actions, but which, without social support, might not have vigor enough to fully assert themselves against countervailing motives. It is impossible, in fact, to understand why the praise is given without understanding at the same time why it is needed.

Again, Professor Calderwood can not understand how, on utilitarian principles, which he regards Mr. Spencer as adopting, *intention* should make so much difference in actions. "Two men might lose their lives by the hands of two of their fellows, and we should call the one a case of murder and the other a case of accidental death." Why—if actions are to be judged solely by their consequences? This is almost too puerile; but, since a Professor of Moral Philosophy at Edinburgh has raised the question, let me simply remark that, while the act of carelessness has no *ulterior* consequences, the act of felony has—or will have if left unpunished—the direst consequences to society. Further, in so far as an act of carelessness is felt to menace society as being likely to lead, if unchecked, to further carelessness, *we do view the matter seriously*, and visit it both with punishment and reprobation. The shipmaster who, through carelessness, loses his ship, has his certificate canceled or suspended. The engine-driver or conductor, through whose carelessness life is sacrificed, finds himself a criminal in the eye of the law. There is this difference, however, between the worst act of carelessness and an act of malignity, that, in the first case, the doer of the act generally suffers more or less in its consequences, and is therefore in a measure punished already; while the willful offender does not feel the wrong he has done, and consequently throws upon society the whole burden of his punishment.

Dr. McCosh, in the "Princeton Review" (November, 1879), touches, perhaps, a weak point in Mr. Spencer's book when he quotes from the chapter on "Absolute and Relative Ethics" the statement that "conduct which has any concomitant of pain, or any painful consequence, is partially wrong." I think we may fairly question Mr. Spencer's right to take the word "wrong" and divorce it so violently from its universally understood meaning as he does in this passage. If he had said that no action can be a *perfect action* "which has any concomitant of pain or any painful consequence," the statement might have passed with the explanation he gives. But to speak of an action which is *the very best that can be done under given circumstances* as "partially wrong," is to strain language unduly. How can it be partially wrong —to cite Dr. McCosh's examples—to submit to an amputation in order to preserve life, or to conquer a vice by painful effort?

Dr. McCosh is probably right, also, in holding that the teaching of the chapter on "Absolute and Relative Ethics" is of somewhat questionable tendency, as leaving altogether too much room for what he calls "the crooked casuistry of the heart." Mr. Spencer's essential meaning I hold to be right; but I hardly think that, considering the novelty of his views, he has been sufficiently guarded in his use of language. He might have said, without in any way betraying his fundamental principles: "The distinction between right and wrong is one that emerges in the region of human, and particularly of social, life; though right and wrong actions, considered as respectively making for or against the preservation and improvement of life, have their analogues in regions lower than the human. A *perfect* action is one all the consequences and relations of which are satisfactory, as tending to happiness or life; and, therefore, no action which has any accompaniment of pain—though the motive of the doer may be of the highest—can be a perfect action. The motive is pure and good, but it has a setting of painful circumstances, and the action as a whole belongs to an imperfect system of life. In practical life we have often to choose between evils, but he who does not choose for the best, when he sees it, violates the highest law of existence." The gist of Mr. Spencer's teaching, in so far as it assumes a moral character, might, I think, be summed up in these words. Taking the book as a whole, and looking, as we are bound to do, at its inner sense, it must, I think, be acknowledged that, while it does not deal with motives or the subjective aspect of morality, the view which it presents of the connections of moral action, the width of its survey over nature, the conclusive manner in which it demonstrates the healthfulness of what is right and the rightness of what is healthful, should tend to confirm in right determinations even those who miss from it what they deem of most importance. To those, on the other hand, who have long been wistfully looking for an exposition of the natural laws and sanctions of morality, it will be a word spoken with power, and in many ways a help toward higher life. There

is but little scandal, after all, if we come to think of it, in supposing that action which we call moral may be a developed form of action to which the name can not be applied; but there is great edification in the thought, now brought home to our understandings, that, by every truly moral act, we help to build up and improve the life of the world and make ourselves co-workers with the principle of life everywhere.

THE COMING OF AGE OF THE ORIGIN OF SPECIES.*

By Professor T. H. HUXLEY.

MANY of you will be familiar with the aspect of this small, green-covered book. It is a copy of the first edition of the "Origin of Species," and bears the date of its production—the 1st of October, 1859. Only a few months, therefore, are needed to complete the full tale of twenty-one years since its birthday.

Those whose memories carry them back to this time will remember that the infant was remarkably lively, and that a great number of excellent persons mistook its manifestations of a vigorous individuality for mere naughtiness; in fact, there was a very pretty turmoil about its cradle. My recollections of the period are particularly vivid; for, having conceived a tender affection for a child of what appeared to me to be such remarkable promise, I acted for some time in the capacity of a sort of under-nurse, and thus came in for my share of the storms which threatened even the very life of the young creature. For some years it was undoubtedly warm work, but, considering how exceedingly unpleasant the apparition of the new-comer must have been to those who did not fall in love with him at first sight, I think it is to the credit of our age that the war was not fiercer, and that the more bitter and unscrupulous forms of opposition died away as soon as they did.

I speak of this period as of something past and gone, possessing merely an historical, I had almost said an antiquarian interest. For, during the second decade of the existence of the "Origin of Species," opposition, though by no means dead, assumed a different aspect. On the part of all those who had any reason to respect themselves, it assumed a thoroughly respectful character. By this time the dullest began to perceive that the child was not likely to perish of any congenital weakness or infantile disorder, but was growing into a stalwart personage, upon whom mere goody scoldings and threatenings with the birch-rod were quite thrown away.

In fact, those who have watched the progress of science within the last ten years will bear me out to the full when I assert that there is no field of biological inquiry in which the influence of the "Origin of

* A lecture delivered at the Royal Institution, Friday, March 19, 1880.

Species" is not traceable; the foremost men of science in every country are either avowed champions of its leading doctrines, or at any rate abstain from opposing them; a host of young and ardent investigators seek for and find inspiration and guidance in Mr. Darwin's great work; and the general doctrine of evolution, to one side of which it gives expression, finds in the phenomena of biology a firm base of operations whence it may conduct its conquest of the whole realm of nature.

History warns us, however, that it is the customary fate of new truths to begin as heresies and to end as superstitions; and, as matters now stand, it is hardly rash to anticipate that, in another twenty years, the new generation, educated under the influences of the present day, will be in danger of accepting the main doctrines of the "Origin of Species" with as little reflection, and it may be with as little justification, as so many of our contemporaries, twenty years ago, rejected them.

Against any such a consummation let us all devoutly pray; for the scientific spirit is of more value than its products, and irrationally-held truths may be more harmful than reasoned errors. Now, the essence of the scientific spirit is criticism. It tells us that, to whatever doctrine claiming our assent, we should reply, Take it if you can compel it. The struggle for existence holds as much in the intellectual as in the physical world. A theory is a species of thinking, and its right to exist is coextensive with its power of resisting extinction by its rivals.

From this point of view it appears to me that it would be but a poor way of celebrating the Coming of Age of the Origin of Species were I merely to dwell upon the facts, undoubted and remarkable as they are, of its far-reaching influence and of the great following of ardent disciples who are occupied in spreading and developing its doctrines. Mere insanities and inanities have before now swollen to portentous size in the course of twenty years. Let us rather ask this prodigious change in opinion to justify itself; let us inquire whether anything has happened since 1859 which will explain, on rational grounds, why so many are worshiping that which they burned, and burning that which they worshiped. It is only in this way that we shall acquire the means of judging whether the movement we have witnessed is a mere eddy of fashion, or truly one with the irreversible current of intellectual progress, and, like it, safe from retrogressive reaction.

Every belief is the product of two factors: the first is the state of the mind to which the evidence in favor of that belief is presented; and the second is the logical cogency of the evidence itself. In both these respects the history of biological science during the last twenty years appears to me to afford an ample explanation of the change which has taken place; and a brief consideration of the salient events

of that history will enable us to understand why, if the "Origin of Species" appeared now, it would meet with a very different reception from that which greeted it in 1859.

One-and-twenty years ago, in spite of the work commenced by Hutton and continued with rare skill and patience by Lyell, the dominant view of the past history of the earth was catastrophic. Great and sudden physical revolutions, wholesale creations and extinctions of living beings, were the ordinary machinery of the geological epic brought into fashion by the misapplied genius of Cuvier. It was gravely maintained and taught that the end of every geological epoch was signalized by a cataclysm, by which every living being on the globe was swept away, to be replaced by a brand-new creation when the world returned to quiescence. A scheme of Nature which appeared to be modeled on the likeness of a succession of rubbers of whist, at the end of each of which the players upset the table and called for a new pack, did not seem to shock anybody.

I may be wrong, but I doubt if at the present time there is a single responsible representative of these opinions left. The progress of scientific geology has elevated the fundamental principle of uniformitarianism, that the explanation of the past is to be sought in the study of the present, into the position of an axiom; and the wild speculations of the catastrophists, to which we all listened with respect a quarter of a century ago, would hardly find a single patient hearer at the present day. No physical geologist now dreams of seeking outside the ranges of known natural causes for the explanation of anything that happened millions of years ago, any more than he would be guilty of the like absurdity in regard to current events.

The effect of this change of opinion upon biological speculation is obvious. For, if there have been no periodical general physical catastrophes, what brought about the assumed general extinctions and recreations of life which are the corresponding biological catastrophes? And if no such interruptions of the ordinary course of nature have taken place in the organic, any more than in the inorganic, world, what alternative is there to the admission of evolution?

The doctrine of evolution in biology is the necessary result of the logical application of the principles of uniformitarianism to the phenomena of life. Darwin is the natural successor of Hutton and Lyell, and the "Origin of Species" the natural sequence of the "Principles of Geology."

The fundamental doctrine of the "Origin of Species," as of all forms of the theory of evolution applied to biology, is "that the innumerable species, genera, and families of organic beings with which the world is peopled, have all descended, each within its own class or group, from common parents, and have all been modified in the course of descent."*

* "Origin of Species," first edition, p. 457.

And, in view of the facts of geology, it follows that all living animals and plants "are the lineal descendants of those which lived long before the Silurian epoch."*

It is an obvious consequence of this theory of Descent with Modification, as it is sometimes called, that all plants and animals, however different they may now be, must, at one time or other, have been connected by direct or indirect intermediate gradations, and that the appearance of isolation presented by various groups of organic beings must be unreal.

No part of Mr. Darwin's work ran more directly counter to the prepossessions of naturalists twenty years ago than this. And such prepossessions were very excusable, for there was undoubtedly a great deal to be said, at that time, in favor of the fixity of species and of the existence of great breaks, which there was no obvious or probable means of filling up, between various groups of organic beings.

For various reasons, scientific and unscientific, much had been made of the hiatus between man and the rest of the higher mammalia, and it is no wonder that issue was first joined on this part of the controversy. I have no wish to revive past and happily forgotten controversies, but I must state the simple fact that the distinctions in cerebral and other characters, which were so hotly affirmed to separate man from all other animals in 1860, have all been demonstrated to be non-existent, and that the contrary doctrine is now universally accepted and taught.

But there were other cases in which the wide structural gaps asserted to exist between one group of animals and another were by no means fictitious; and, when such structural breaks were real Mr. Darwin could account for them only by supposing that the intermediate forms which once existed had become extinct. In a remarkable passage he says: "We may thus account even for the distinctness of whole classes from each other—for instance, of birds from all vertebrate animals—by the belief that many animal forms of life have been utterly lost, through which the early progenitors of birds were formerly connected with the early progenitors of the other vertebrate classes."†

Adverse criticism made merry over such suggestions as these. Of course it was easy to get out of the difficulty by supposing extinction; but, where was the slightest evidence that such intermediate forms between birds and reptiles as the hypothesis required ever existed? And then probably followed a tirade upon this terrible forsaking of the paths of "Baconian induction."

But the progress of knowledge has justified Mr. Darwin to an extent which could hardly have been anticipated. In 1862 the specimen of *Archæopteryx*, which until the last two or three years has remained unique, was discovered; and it is an animal which, in its feathers and the greater part of its organization, is a veritable bird, while, in other parts, it is as distinctly reptilian.

* "Origin of Species," first edition, p. 458. † Ibid., p. 431.

In 1868 I had the honor of bringing under your notice, in this theatre, the results of investigations made, up to that time, into the anatomical characters of certain ancient reptiles, which showed the nature of the modifications in virtue of which the type of the quadrupedal reptile passed into that of the bipedal bird; and abundant confirmatory evidence of the justice of the conclusions which I then laid before you has since come to light.

In 1875 the discovery of the toothed birds of the cretaceous formation in North America, by Professor Marsh, completed the series of transitional forms between birds and reptiles, and removed Mr. Darwin's proposition, that "many animal forms of life have been utterly lost, through which the early progenitors of birds were formerly connected with the early progenitors of the other vertebrate classes," from the region of hypothesis to that of demonstrable fact.

In 1859 there appeared to be a very sharp and clear hiatus between vertebrated and invertebrated animals, not only in their structure, but what was more important, in their development. I do not think that we even yet know the precise links of connection between the two; but the investigations of Kowalewsky and others upon the development of *Amphioxus* and of the *Tunicata* prove beyond a doubt that the differences which were supposed to constitute a barrier between the two are non-existent. There is no longer any difficulty in understanding how the vertebrate type may have arisen from the invertebrate, though the full proof of the manner in which the transition was actually effected may still be lacking.

Again, in 1859 there appeared to be a no less sharp separation between the two great groups of flowering and flowerless plants. It is only subsequently that the series of remarkable investigations inaugurated by Hofmeister has brought to light the extraordinary and altogether unexpected modifications of the reproductive apparatus in the *Lycopodiaceæ*, the *Rhizocarpeæ*, and the *Gymnospermeæ*, by which the ferns and the mosses are gradually connected with the Phanerogamic division of the vegetable world.

So, again, it is only since 1859 that we have acquired that wealth of knowledge of the lowest forms of life which demonstrates the futility of any attempt to separate the lowest plants from the lowest animals, and shows that the two kingdoms of living nature have a common border-land which belongs to both or to neither.

Thus it will be observed that the whole tendency of biological investigation since 1859 has been in the direction of removing the difficulties which the apparent breaks in the series created at that time; and the recognition of gradation is the first step toward the acceptance of evolution.

As another great factor in bringing about the change of opinion which has taken place among naturalists, I count the astonishing progress which has been made in the study of embryology. Twenty

years ago, not only were we devoid of any accurate knowledge of the mode of development of many groups of animals and plants, but the methods of investigation were rude and imperfect. At the present time there is no important group of organic beings the development of which has not been carefully studied, and the modern methods of hardening and section-making enable the embryologist to determine the nature of the process in each case, with a degree of minuteness and accuracy which is truly astonishing to those whose memories carry them back to the beginnings of modern histology. And the results of these embryological investigations are in complete harmony with the requirements of the doctrine of evolution. The first beginnings of all the higher forms of animal life are similar, and, however diverse their adult conditions, they start from a common foundation. Moreover, the process of development of the animal or the plant from its primary egg or germ is a true process of evolution—a progress from almost formless to more or less highly organized matter, in virtue of the properties inherent in that matter.

To those who are familiar with the process of development all *a priori* objections to the doctrine of biological evolution appear childish. Any one who has watched the gradual formation of a complicated animal from the protoplasmic mass which constitutes the essential element of a frog's or a hen's egg has had under his eyes sufficient evidence that a similar evolution of the animal world from the like foundation is, at any rate, possible.

Yet another product of investigation has largely contributed to the removal of the objections to the doctrine of evolution current in 1859. It is the proof afforded by successive discoveries that Mr. Darwin did not over-estimate the imperfection of the geological record. No more striking illustration of this is needed than a comparison of our knowledge of the mammalian fauna of the Tertiary epoch in 1859 with its present condition. M. Gaudry's researches on the fossils of Pikermi were published in 1868, those of Messrs. Leidy, Marsh, and Cope on the fossils of the Western Territories of America have appeared almost wholly since 1870 ; those of M. Filhol, on the phosphorites of Quercy, in 1878. The general effect of these investigations has been to introduce us to a multitude of extinct animals, the existence of which was previously hardly suspected ; just as if zoölogists were to become acquainted with a country, hitherto unknown, as rich in novel forms of life as Brazil or South Africa once was to Europeans. Indeed, the fossil fauna of the Western Territories of America bids fair to exceed in interest and importance all other known Tertiary deposits put together ; and yet, with the exception of the case of the American tertiaries, these investigations have extended over very limited areas, and at Pikermi were confined to an extremely small space.

Such appear to me to be the chief events in the history of the progress of knowledge, during the last twenty years, which account

for the changed feeling with which the doctrine of evolution is at present regarded by those who have followed the advance of biological science in respect of those problems which bear indirectly upon that doctrine.

But all this remains mere secondary evidence. It may remove dissent, but it does not compel assent. Primary and direct evidence in favor of evolution can be furnished only by paleontology. The geological record, so soon as it approaches completeness, must, when properly questioned, yield either an affirmative or a negative answer; if evolution has taken place, there will its mark be left; if it has not taken place, there will lie its refutation.

What was the state of matters in 1859? Let us hear Mr. Darwin, who may be trusted always to state the case against himself as strongly as possible.

"On this doctrine of the extermination of an infinitude of connecting links between the living and extinct inhabitants of the world, and at each successive period between the extinct and still older species, why is not every geological formation charged with such links? Why does not every collection of fossil remains afford plain evidence of the gradation and mutation of the forms of life? We meet with no such evidence, and this is the most obvious and plausible of the many objections which may be urged against my theory." *

Nothing could have been more useful to the opposition than this characteristically candid avowal, twisted as it immediately was into an admission that the writer's views were contradicted by the facts of paleontology. But, in fact, Mr. Darwin made no such admission. What he says in effect is, not that paleontological evidence is against him, but that it is not distinctly in his favor; and, without attempting to attenuate the fact, he accounts for it by the scantiness and the imperfection of that evidence.

What is the state of the case now, when, as we have seen, the amount of our knowledge respecting the mammalia of the Tertiary epoch is increased fifty-fold, and in some directions even approaches completeness?

Simply this, that, if the doctrine of evolution had not existed, paleontologists must have invented it, so irresistibly is it forced upon the mind by the study of the remains of the Tertiary mammalia which have been brought to light since 1859.

Among the fossils of Pikermi, Gaudry found the successive stages by which the ancient civets passed into the more modern hyenas; through the Tertiary deposits of Western America, Marsh tracked the successive forms by which the ancient stock of the horse has passed into its present form; and innumerable less complete indications of the mode of evolution of other groups of the higher mammalia have been obtained.

* "Origin of Species," first edition, p. 463.

In the remarkable memoir on the phosphorites of Quercy, to which I have referred, M. Filhol describes no fewer than seventeen varieties of the genus *Cynodictis* which fill up all the interval between the viverine animals and the bear-like dog *Amphicyon;* nor do I know any solid ground of objection to the supposition that in this *Cynodictis-Amphicyon* group we have the stock whence all the Viveridæ, Felidæ, Hyænidæ, Canidæ, and perhaps the Procyonidæ and Ursidæ, of the present fauna have been evolved. On the contrary, there is a great deal to be said in its favor.

In the course of summing up his results, M. Filhol observes:

"During the epoch of the phosphorites, great changes took place in animal forms, and almost the same types as those which now exist became defined from one another.

"Under the influence of natural conditions of which we have no exact knowledge, though traces of them are discoverable, species have been modified in a thousand ways: races have arisen which, becoming fixed, have thus produced a corresponding number of secondary species."

In 1859, language of which this is an unintentional paraphrase, occurring in the "Origin of Species," was scouted as wild speculation; at present, it is a sober statement of the conclusions to which an acute and critically-minded investigator is led by large and patient study of the facts of paleontology. I venture to repeat what I have said before, that, so far as the animal world is concerned, evolution is no longer a speculation, but a statement of historical fact. It takes its place alongside of those accepted truths which must be taken into account by philosophers of all schools.

Thus when, on the first day of October next, the "Origin of Species" comes of age, the promise of its youth will be amply fulfilled; and we shall be prepared to congratulate the venerated author of the book, not only that the greatness of his achievement and its enduring influence upon the progress of knowledge have won him a place beside our Harvey; but, still more, that, like Harvey, he has lived long enough to outlast detraction and opposition, and to see the stone that the builders rejected become the head-stone of the corner.—*Nature.*

ATMOSPHERIC DUST.*

By GASTON TISSANDIER.

EVERY one is aware that the atmosphere holds quantities of dust in suspension. The dust betrays its presence by settling upon our clothes, furniture, and other objects, but, on account of the minuteness of its particles, it can not be seen as it floats in the air, except under

* Translated and abridged from the "Revue Scientifique."

the illumination of a strong light, as in the case of a sunbeam shining into a dark room. Besides the grains of dust which may be seen in this manner, there are others that can be perceived only through the microscope, and others smaller still, little nothings like nebulosities in the sky, which seem to become more numerous as they are sought for with more powerful instruments. These bits of dust, lifted up and carried hither and thither by the atmospheric currents, must not be overlooked, for they play a part of considerable importance in terrestrial economy, and give rise to real geological formations. Clouds of impalpable dust, falling from the air in showers of considerable abundance, are not uncommon in some countries, and have been noticed in all periods of history. Showers of blood have also been mentioned quite often from the times of Homer down; they are showers of rain-water made muddy with the atmospheric dust, and bearing a yellow or reddish deposit. Showers of dust, both dry and wet, are quite frequent in the Cape de Verd Islands, and are called red fogs by the sailors. They are also common in Sicily and Italy, and occur so often in some parts of China as hardly to attract remark. The Chinese account for them by saying that the dust is lifted up by whirlwinds in the Desert of Gobi, is carried by the aërial currents into the higher regions of the atmosphere, falls at a distance, and is then swept up by rain-waters and carried by the rivers to be deposited at the bottom of the Yellow Sea. A shower of very fine dust which fell in southern France in October, 1846, was found, by the analyses of M. Dumas and the microscopic tests applied by M. Ehrenberg, to be composed of the fine sands of Guiana and to contain the characteristic diatoms and microscopic shells of South America.

FIG. 1.—CORPUSCLES EXTRACTED BY THE MAGNET FROM THE DUST DEPOSITED ON A SURFACE OF TWELVE SQUARE METRES AT SAINTE-MARIE-DU-MONT, MANCHE. (600 Diameters.)

Some of these showers originate in volcanic eruptions, from which fine ashes are projected up into the atmosphere, transported to a distance, and deposited over regions of considerable extent. A volcano of the Island of Sumbawa, in 1815, covered with ashes a space of three or four times the extent of France; the event left such an impression that the people at Bruni, in Borneo, made it an epoch from which they reckoned their dates. In some places the atmospheric currents of dust exert a perceptible mechanical action. Sir Joseph Hooker remarked, when he was in South America, that the aërial sand-currents on the tops of high mountains were competent to wear down and polish the trunks of trees and produce striæ upon them like that made upon rocks by glacial action. M. Videt d'Aoust has found evidence in Mexico

of the formation of beds by the settlement of the dust, covering the largest mountains, as Popocatepetl and Orizaba, rising to the height of about 12,000 feet on the slopes and reaching a thickness in the valleys of from 250 to 325 feet. These formations are occasioned by whirlwinds of dust which are frequent on the Mexican plain, and are stopped by the elevated chain of the mountains, as the mud in a river is stopped by a sand-bar. The action of the prevailing winds in other parts of the globe promotes the formation of similar deposits, which may be called aërial lands.

These are the dusts of the lower regions of the atmosphere. But the air contains other particles in the most minute degree of division. The waters of the sea, impinging on the coast in waves, are broken into thousands of particles which are taken up and evaporated by the winds. The saline residue of these particles adds a new element to the atmospheric dust; the vapors furnished by the sea go to the formation of clouds and fogs. Rising beyond the regions of ordinary clouds, these vapors ascend to the colder strata, where they are converted into a dust consisting of minute crystals of ice which form the cirrhus clouds and the ice-fields of the upper regions. These masses of frost, which can only be distinguished when they are approached by a balloon, but the existence of which is well established, are agents in the formation of halos and parhelia, and descend in cold winds to the surface.

FIG. 2.—CORPUSCLES EXTRACTED BY THE MAGNET FROM THE SEDIMENT OF RAIN-WATER AT SAINTE-MARIE-DU-MONT, MANCHE. (500 Diameters.)

If we pass these heights, into the extreme limits of the atmosphere, we shall find ourselves in the presence of dust from a new source—of that which is furnished by the combustion of incandescent aërolites. The fruits of the study of meteoric astronomy prove that the surface of the earth is continually receiving cosmic materials either in the form of meteorites or shooting-stars, or of an impalpable dust. A ship passing to the south of Java in January, 1859, was assailed by a very fine ferruginous dust. Ehrenberg examined some of it with the microscope, and found that it was formed of melted globules of oxide of iron, and did not hesitate to regard it as consisting of particles of a mass of meteoric iron, which had been melted off by the operations of atmospheric friction. In other cases the particles may originate in the disintegration of the substance of the meteors, when the soluble salts with which they are cemented are dissolved by atmospheric moisture, as Daubrée observed in the case of a meteorite at Orgueil. Showers of fire have been mentioned, or of sparks which seem to be formed of

the incandescent dust of aërolites. Baron Reichenbach collected on the summit of Lahisberg a black ferruginous dust containing traces of nickel and cobalt, which incontestably indicated its cosmic origin. Mr. Nordenskjöld collected a similar dust from off the snow of the polar regions.

For several years I have paid attention to the study of atmospheric dust, and believe that I have proved that more or less considerable quantities of dust derived from cosmic bodies are constantly present in the air. The greater part of my experiments have been performed in the meteorological observatory of Sainte-Marie-du-Mont, Manche, where M. Hervé-Mangon has placed the resources of his establishment and laboratory at my disposition. I have endeavored to collect large quantities of dust, so that I might carry on microscopic and chemical analyses with precision. For this purpose I used a surface of paper of two square metres, which I exposed horizontally to the air; I collected from it the dust which fell from the air, sweeping it up with a small brush. I called this apparatus a dust-table. The weight of the dust collected upon this surface at Sainte-Marie-du-Mont varied from two to nine milligrammes (.03 to .14 grains troy) in twenty-four hours. The particles shown in Fig. 1 represent minute grains of magnetic oxide of iron, which were drawn out from the dust by the magnet. They are greatly magnified, their real diameter being only $\frac{1}{10}$ of a millimetre ($\frac{4}{1000}$ of an inch).

If we evaporate considerable volumes of rain-water, we shall obtain a sediment which represents the air-dust; if, then, we draw a magnet through this sediment, we shall nearly always find little globules of magnetic oxide of iron in it. Fig. 2 represents some of these globules, which I extracted from one hundred quarts of rain-water at Sainte-Marie-du-Mont.

We can distinguish several of these grains which have the form of spherules, or granules that have undergone fusion. The sediment from rain-water collected in Paris at the School of Bridges and Highways at the Trocadéro and the dust collected in one of the towers of Notre Dame gave identical results (Fig. 3).

FIG. 3.—CORPUSCLES EXTRACTED BY A MAGNET FROM THE DUST BROUGHT IN BY THE WIND IN A TOWER OF NOTRE DAME WHICH IS CLOSED TO VISITORS. (500 Diameters.)

These facts prove conclusively that the air holds in suspension minute microscopic particles of oxide of iron, some of which assume the form of well-defined spherules.

Similar spherules may be found everywhere in the dust of the air and in rain-water and snow-water. I have found them in the sedi-

ment of snow-water collected at the height of 8,800 feet on Mont Blanc (Fig. 4). Since I have called attention to the existence of these ferruginous bodies in the air, several men of science have confirmed my observations, particularly M. Yung, of the University of Geneva, and MM. Schoenaur and Pierre Miquel, who have pursued the study of the

FIG. 4.—CORPUSCLES EXTRACTED BY THE MAGNET FROM THE SEDIMENT OF SNOW-WATER ON MONT BLANC, 8,800 FEET ABOVE THE SEA. (500 Diameters.)

air-dust at the observatory of Montsouris under the direction of M. Marie-Davy.

Whence are these ferruginous particles derived? The spherules have been melted: we can prove this by burning particles of iron and observing them under the microscope (Fig. 5); those which fly off on the striking of a flint are like them (Fig. 6). The spherules we are considering are probably derived from the showers of fire that escape

FIG. 5.—GLOBULES OF MAGNETIC OXIDE OF IRON OBTAINED BY BURNING FINE IRON FILINGS IN A HYDROGEN FLAME. (500 Diameters.)

from incandescent meteorites. I have been confirmed in this view by observing with the microscope the crust of the aërolites in the collection of the Museum of Natural History, in which were perceived rounded grains having considerable resemblance to those we have just noticed. Moreover, the magnetic particles withdrawn from atmospheric sediments have given on analysis reactions indicating the pres-

FIG. 6.—SPHERICAL GLOBULES OF MAGNETIC OXIDE OF IRON OBTAINED BY COLLECTING THE SPARKS STRUCK OFF BY A FLINT. (250 Diameters.)

ence of nickel; of a character, consequently, to cause them to be regarded as partaking of the nature of meteorites. It may be objected that metallurgical operations and the production of oxides in iron-works give rise to similar ferruginous corpuscles. This is true; but how can we explain the presence of the spherules in geological formations that have not been worked over, where they must have been left previous to the existence of man on the earth? M. Stanislaus Meunier and I have found in the grits below the Lias, in the micaceous slates of the

Trias, magnetic globules like the spherules which now fall from the atmosphere upon the earth ; we may, according to our theory, consider them fossil meteorites.

Beautiful and peculiar crystalline forms (Fig. 7) are obtained when a drop of rain-water or snow-water is evaporated to dryness, the substance of which consists of the nitrate of ammonia contained in meteoric waters.

The dusts that are produced by man in works of industry expose him to terrible dangers. Stone-dressers breathe very minute particles of grit

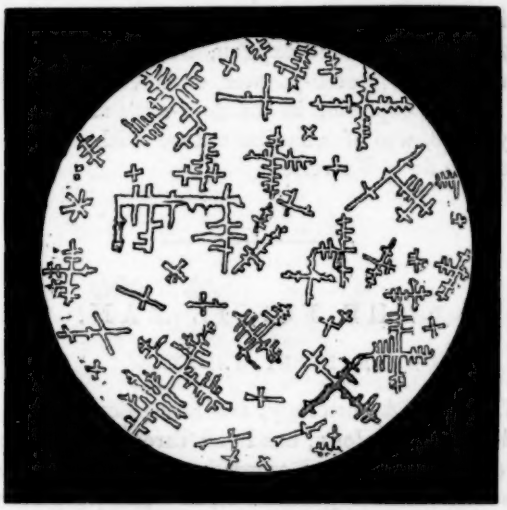

FIG. 7.—CRYSTALS OBTAINED BY EVAPORATING TO DRYNESS A DROP OF SNOW-WATER. (500 Diameters.)

which perceptibly injures the lungs ; the dust of white-lead, and that of the arsenite of copper, which is used to color cloths and papers, have often produced genuine poisonings. The dust of coal, with which the galleries of coal-mines are filled, is breathed by the miners, and produces an affection which Dr. Riembault, of St.-Etienne, has designated as the carbonaceous obstruction of the lungs of miners. He has dissected the lungs of workmen who had labored in the mines for a greater or less length of time, and has found that this pulmonary obstruction goes on continually increasing till it becomes very dangerous. Sections of the lungs of miners show a gradual progress of coloration, from the fresh, rosy color of the lungs of a person who has always lived in the open air, to gray after a few years, and a blackness approaching that of the coal itself after forty years of labor in the mines. The dust of coal in the mines, when raised up and ignited, either by a blast or by the burning of a little carburetted hydrogen, has sometimes spread fires to great distances in the galleries, burning the workmen and producing terrible catastrophes. M. Galloway has made some impor-

tant researches on this subject, and has shown that, even if the dust of coal is not directly inflammable, it becomes very combustible when the atmosphere contains traces of carburetted hydrogen. Other dusts are directly combustible, and sometimes produce genuine catastrophes by the fact of their suspension in the air. In 1869 a sack of starch was accidentally thrown down from the top of a staircase in the Rue de la Verrerie, Paris; it burst and scattered through the air a cloud of dust which took fire from the contact with a gaslight at the bottom of the stairs, and caused an explosion. M. Berthelot has observed that special conditions of mixture are required for the actual production of such explosions, and that a hundred cubic metres of air, containing about thirty kilogrammes of oxygen, will completely burn twenty-seven kilogrammes of starch-powder, or eleven kilogrammes of coal-dust. The terrible explosion in the flour-mills at Minneapolis, Minnesota, in May, 1878, was of a similar nature with the explosion of the starch in the Rue de la Verrerie.

THE FOSSIL MAN.

By HENRY W. HAYNES.

PREHISTORIC Archæology, the latest-born of the sciences, like her elder sister Geology, has lived through the successive stages of scornful denial, doubt, and unwilling assent, and has finally won for herself substantial recognition. The "antiquity of man" is now an established fact. Even its most strenuous opponents are forced to concede that there are proofs of his existence during a lapse of time far exceeding the limits of the previously approved chronology. For somewhat of the suspicion with which this result has been received, certain of its advocates may have themselves to blame. Where absolute chronological determinations were of necessity impossible, and where, even at the present stage of the investigation, only general approximations can be reached, it was at least injudicious to startle received opinions, and to arouse prejudices, by asserting for mankind an antiquity of hundreds of thousands of years. Moreover, the great name of Cuvier was held up as a barrier in the path of those who claimed to have discovered proofs of man's existence under geological conditions differing from the present. Cuvier, however, never *denied the possibility* of finding "the fossil man"; he only questioned the sufficiency of the evidence of his existence which had been brought under his notice, and with great reason, in view of the numerous instances in which pretended fossil human bones had turned out to be those of animals, or even merely natural formations.

Many have been the definitions given of the term "*fossil*"; but

by the phrase "the fossil man" is intended in this article *man as the contemporary* of certain species of animals now either *totally or locally extinct*, which we know only from their bones, *dug out* of the earth, but as to whose existence history and tradition are silent. Such animal remains are found, mingled with those of species still living; but they occur under geological conditions which show that the formerly existing surface of the earth differed in certain respects from its present state. This geological epoch, the nearest in point of time to the present, is called the Quaternary period. It is characterized by extensive deposits of rolled and water-worn pebbles, gravels, and clays, underlying the cultivable surface-soil, and due to the action of former extensive glaciers and of great and rapid currents of water. These latter were produced by the melting of that sheet of snow and ice which once covered large regions of the northern portions of Europe and America, combined with a climate much more humid than the present, and a consequent greater rainfall. This moister climate arose from a different relative arrangement of the then existing continents and seas. The general contour of the earth's surface, then, so far as existing elevations are concerned, seems to have resembled very nearly its present appearance; thus these great currents in many instances took the courses of the present river-systems in northern and central Europe and North America. The Quaternary deposits, consequently, have often been left in the neighborhood of existing streams, which now seem like shrunken rivulets in comparison with these mighty rivers of old. Through these deposits and the underlying strata the present rivers have cut their channels, leaving the Quaternary gravel-beds sometimes as high up as two hundred feet on the slopes of their valleys. In some cases oscillations of level of the surface, or other causes, have left such deposits where there are no longer existing rivers. They are, however, all characterized by similar features, and are called by geologists indifferently *Quaternary gravels* or *drift;* while the beds composed of the finer particles, often of great thickness and spread like a carpet over extensive plateaus, are named *loess* or *brick-earth*. That such beds of gravel or loess were not deposited by the sea is proved by the fact that such animal remains as occur in them are all those of land or fresh-water, and never those of marine, species.

But it is not only in the Quaternary gravels and loess that the bones of extinct animals are found; they occur more frequently in numerous caverns and fissures in the rocks. As these are met with most commonly in limestone formations, the bones are in consequence generally imbedded in or covered by a stalagmitic formation, produced by the percolation through the roof of water charged with carbonate of lime. Such a floor of stalagmite, sometimes of great thickness, covering and completely sealing up the contents of the underlying beds, is at once a proof of their antiquity and a guarantee against the possibility of such contents having become confused with objects of a later date.

In such Quaternary gravels and caverns mingled with the bones of numerous extinct species of animals, such as the mammoth, the woolly rhinoceros, and the cave-bear and others, human bones have been discovered, although comparatively rarely, while the implements and objects of man's fabrication are found in large quantities. They are, however, all made of stone, or of the horns and bones of animals. Such human remains as have been discovered show man at this earliest epoch to have been possessed of a cranial development quite equal to the average now. Already the anthropologists have been able to establish the existence of at least three different races, named, from the localities in which the skulls have been discovered, the races of Canstadt, of Cro-Magnon, and of Furfooz—caverns situated respectively in Germany, in France, and in Belgium. But implements and weapons of undoubted human workmanship are as good proof of man's existence as his actual bones; nor is the scarcity of these latter limited to Quaternary times. None were found, for example, when the great Haarlaem Lake was drained, although many a bloody sea-fight had taken place on its broad bosom.

Nor is it in rare and special localities alone that traces of early man have been found. They are met with in England, in France, in Belgium, in Switzerland, in Germany, in Italy, in Spain and Portugal, and in southern India; and in the winter of 1878 I was fortunate enough to discover them in Upper Egypt, where hitherto their occurrence has been either denied or doubted. Our own continent, too, seems to be not wanting in them, as within the past few years they appear to have been discovered by Dr. Abbott in the glacial drift of the valley of the Delaware. The field is vast and the laborers have been few, but their numbers are rapidly increasing; and, as extended research has been constantly rewarded by repeated discovery, we have every reason to expect that there are most important results yet to be reached, both on this continent and in the almost unexplored regions of Asia, the acknowledged cradle of the human race, where thus far only slight traces of early man have been met with.

But though the antiquity of man is admitted, and the fact of his coexistence with extinct animals during the Quaternary period can not be denied, yet both the duration of the Quaternary period and the question of his existence in the previous Tertiary age are still stoutly contested. The proofs of his presence in Tertiary times are as yet "few and far between," and the believers in his existence at that remote epoch are by no means numerous; still, as History so oft repeats herself, it may well happen that the late Abbé Bourgeois, of Pontlevoy, who has been thus far the principal champion of the Tertiary man, may share in the eyes of posterity in the well-merited honors of Boucher de Perthes, of Abbeville, who first established the existence of "the fossil man." Whether the duration of Quaternary times extends over a period of one hundred thousand years or more, or twenty thousand, or

even less, is immaterial, and probably never can be absolutely determined. The chronological scale is too uncertain, with conditions varying according to locality and circumstances, to give ground for great hope of success. Still, who shall venture to set a limit to the triumphs of science? The methods of prehistoric archæology are scientific; its votaries are steadily increasing in numbers; its progress has been marvelously rapid, and we may with confidence await the result.

The most remote *historical* date thus far even approximately determined is that of the early dynasties of Egypt, although even on this point the authorities differ by as much as a thousand years. Taking, however, the lowest computation, we find, some four thousand years B. C., a flourishing civilization established in Egypt, with a condition of the arts, especially of statuary and of architecture, fully able to stand the test of comparison with those of the present day, but which afterward steadily degenerated under the iron rule of the priesthood. This date has been reached by the light of written inscriptions, so that the *history* of mankind has thus been carried back to a point of time as remote as that of his creation, according to the belief of our fathers. Now, a flourishing civilization with admirable arts, and especially a fixed literary language, presupposes ages of development and progress, so that we see the "prehistoric man" thrust thus at least one stage into "the dark backward and abysm of time." But only monuments inscribed by Nature's own hand are our helpers in the arduous task of attempting to measure by a scale of centuries the duration of the existence of "the fossil man." The slow excavation of certain river-beds during the present geological period, thus bringing to light in their banks relics of man, above which the soil has accumulated in depths varying according to known historical periods; the secular growth of peat-mosses and of films of stalagmite; the deposit of cones of detritus at the mouths of mountain-torrents; the leisurely filling up of lakes by the accumulation of soil washed down from neighboring mountains —such are the sole standards of measurement that have thus far been devised for the careful computations or the wild guesses of those who have hitherto essayed the difficult problem. Its final determination must properly be left to the geologists, some of whom regard the Quaternary period as more justly to be assigned to the present stage of the earth's history than as constituting a past geological epoch rightly so called. But the discovery of traces of early man in regions widely remote from each other, and especially in countries where the earliest civilizations have arisen, is a complete answer to the objections of those who would make of "the fossil man" only a savage race localized in western Europe in times not far removed from those of which history takes cognizance.

Among the many attempts that have been made to reach a solution of the problem, the most satisfactory, perhaps, have been the systematic explorations that have been carried on without interruption since

1865, by a most competent committee of the British Association, of a large cavern in south Devonshire, near Torquay, called "Kent's Hole." I have had the opportunity of personally studying the modes of procedure there under the guidance of Mr. Pengelly, secretary of the committee, and can bear testimony to the scrupulous care, the vigilant watchfulness, and the great skill and knowledge with which the investigations are prosecuted. The following is a brief sketch of what has been discovered in the course of the exploration: The bottom of the cavern was found to be encumbered with huge blocks of limestone that had become detached from the roof, between and under which was a layer of vegetable mold of varying depths up to a foot or more. In this layer were found objects of various periods, running back as far as the times of the Roman occupation of the island. Below this came a floor, a stalagmite of an average thickness of sixteen to twenty inches, and underneath it a layer of cave-earth four feet deep, in which were found objects of man's fabrication. Still lower they came upon a second floor of stalagmite, which in some places had attained a thickness as great as twelve feet. Below all came a breccia, in which were found numerous teeth and bones of the cave-bear, and with them three undoubted flint instruments. Now, in one part of the cavern there is a huge boss of stalagmite rising from the floor, and on it is inscribed "Robert Hedges, of Ireland, February 20, 1688." For nearly two hundred years the process of the formation of stalagmite appears to have been going on, and still the letters are now only covered by a film of not more than one twentieth of an inch in thickness. Even granting that the deposition of stalagmite may have proceeded much more rapidly under former conditions than at present, when more water and more carbonic acid may have penetrated the cavern, still it is evident what a lapse of time is required to account for the formation of such a mass of material as we have here. Nor can accident or fraud be invoked to explain the presence of these relics of man, under the circumstances in which these have been found. The work was executed under the daily supervision of the committee, and by trustworthy laborers, and no intermingling of objects falling from a higher level; no burying of them in later times in excavations made in an older deposit; no attempt at making gain from forged articles palmed off upon credulous collectors in this case is possible. Like results have been reached by the same committee in the "Brixhaw Cave," on the opposite side of Torbay, which was purchased and thoroughly explored by them immediately after its accidental discovery in 1858, through its roof having been broken into in quarrying. In this case the additional guarantee was afforded for the genuineness of the contents, that its exploration was almost contemporaneous with its discovery. Space will not allow more than an allusion to the laborious and fruitful researches of the late Messrs. Lartet and Christy in the caves and the rock-shelters of the valley of the Dordogne and its affluents,

in the south of France. By their labors and those of the numerous band of explorers who have followed in their footsteps in the same country, and by the discoveries of M. Dumont in the valley of the Meuse in Belgium, we have been enabled to gain some definite knowledge in regard to "the fossil man," his manner of life, his implements and weapons, and even his artistic capabilities.

The "classic ground," however, for the student of prehistoric science must ever be the Somme Valley, from Abbeville to Amiens. From its Quaternary gravels came those rude flint implements with which Boucher de Perthes succeeded at last in silencing the cavils of the incredulous, and establishing the coexistence of man with extinct species of animals. St. Acheul, an old abbey close to Amiens, has given the name to these objects, which are the most ancient type of man's workmanship hitherto met with, for in its vicinity they have been found in greater quantities than in any other locality. When first discovered they were called by the workmen "cats' tongues," from their shape and roughness. In outline, form, and general appearance they are perfectly characteristic, and they differ entirely from all other stone implements which have ever been discovered under different conditions. No one who is at all familiar with the subject can possibly confound one of these *palæolithic* axes, as they are called, roughly chipped and unground, with one of the *neolithic* or polished-stone times. These latter are found in large numbers, and substantially resembling each other all the world over, and are mainly relied upon to prove that everywhere man has at some time lived in a stage of culture, in which he had not attained to the knowledge of the use of metals. The palæolithic weapons, however, or the St. Acheul axes, are of much rarer occurrence. But, if a collection of specimens from various localities, including our own country, be placed side by side, their resemblance to each other will be found to be most striking. At St. Acheul I had the satisfaction of seeing dug out in my own presence, from gravel-pits now more than a quarter of a mile from the river, and one hundred feet or more above its present level, and in a spot overtopped by no higher ground from which anything could possibly have been washed down, two such implements. These, though unfortunately broken, are yet as convincing, from their excellence of workmanship, as if they were still perfect. In this case there was no possibility of deception, through their having been buried beforehand, for me to see them dug out, since I came to the spot unannounced. The workmen at this place know well the value of such objects, and have the habit of fabricating them for sale. If, however, one of their forgeries be placed by the side of a genuine object, there will be found to exist certain infallible tests by which to discriminate between them, so that there need be no mistake. Freshly broken flint presents a peculiar dull and raw surface, entirely unlike the glossy, varnished appearance of objects which have undergone a long exposure to atmos-

pheric influences, and have been subjected to chemical changes and the friction of sand and water. These causes produce the characteristic "patina," which distinguishes genuine flint implements, and which varies greatly according to the conditions under which the objects have remained. It is of very different colors, but has never been successfully imitated by artificial means. Many of the implements also, like mine, are marked by a beautiful moss-like deposit of oxide of manganese, called "dendrites," which is an additional guarantee of their genuineness, as it is only produced by a long lapse of time. In the gravel-pits in the neighborhood of Paris, on both banks of the Seine, in many visits ranging over several years, I have been able to procure a large number of worked flints, together with the usual fossil bones that accompany them. So, too, in similar excavations at the Ponte Molle, near Rome, at a long distance from the present bed of the Tiber, and far above the limit of any possible inundation now, I have obtained numerous specimens both of flints and bones.

To go thoroughly over the arguments of the geologists, by which the very great antiquity of such Quaternary deposits with their contents has been established, would require more space than is at my command. I will simply state a few facts, leaving others to draw their own inferences from them. Implements of the St. Acheul type have been found in place at the bottom of undisturbed gravel-beds more than thirty feet deep, both at Abbeville and at Amiens, and in the former locality peat-beds have been subsequently formed in the more deeply excavated portion of the valley more than thirty feet in thickness. Now, whatever may be the lapse of time needful for the accumulation of such a mass of peat as this, it is all posterior in date to the ancient implement-bearing gravels. At Amiens Roman graves have been found in the superficial deposits at about the present level of the river, and far below that of the Quaternary gravels, showing that more than fifteen hundred years have produced scarcely any change in the configuration of the valley, so far as its depth is concerned. So, too, on the top of Milford Hill, in the neighborhood of Salisbury, England, are found Quaternary gravels containing implements of the St. Acheul type. This hill is cut off from the main spur to which it belongs by a transverse valley, which proves that, at the time when the gravel was deposited there, such a depression could not have existed, as in that case the water would have flowed along the valley, and not left its contents on the top of the hill. On each side of the hill is also a similar valley, which, for the same reason, could not have been there when the gravel was deposited. Thus the top of the hill once formed the bottom of the bed of a river flowing along a valley whose sides have now entirely disappeared, and in their place a new valley has been excavated on each side to the depth of one hundred feet.

That these Quaternary gravels can not be owing to any sudden

cataclysm is proved both by the regularity with which they are deposited, and by the fact that the materials of one river-system are never found mingled with those of another. For example, the gravel-beds of the Somme Valley are entirely composed of *débris* from the chalk and Tertiary strata occupying that area. But within a very few miles of the head-waters of the Somme comes the valley of the Oise. This latter valley contains the remains of other and older strata, none of which have ever found their way into the Somme Valley, as would certainly have been the case if any great and sudden inundation had ever swept over the surface of the whole country.

From such considerations as these, and many others that might be brought forward, prehistoric archæologists are united in the opinion that the St. Acheul axes found in these Quaternary deposits, and in certain caverns, accompanying the bones of the same fossil animals, are relics of the earliest phase of man's existence yet discovered. Of course, the few are excepted who maintain the belief in the Tertiary man. Such implements have been searched for and found in many countries, but there was still one unfortunate hiatus in the line of argument. It was objected, if such evidence of the great antiquity of man has been discovered in so many different regions, Why is it not to be found in Egypt, the oldest country of which we have direct historical knowledge? This question several have attempted to answer, but hitherto they have failed of complete success. This was owing to the nature of the case, and the peculiarities of the country. Most travelers spend the winter months in their *dahabeeahs*, ascending and descending the Nile, and have little leisure for long and patient researches; while the distinguished scholars who have resided for long periods in the country have been exclusively occupied with studying its numerous historical monuments, and no one of them has had any special acquaintance with or interest in the *prehistoric question*. It is true that M. Adrien Arcelin and Sir John Lubbock, and also Dr. Haury with M. Lenormant, who all made the usual Nile trip, have published articles on the subject, some of them figuring in plates certain worked flints discovered by them in Egypt. But they did not succeed in satisfying prehistoric students that they had actually discovered evidence of the *Palæolithic age* in that country. That they had indeed found *worked flints* there, could not be questioned by any one who has had competent experience in the subject, though even this has been denied by the distinguished Egyptologist, Lepsius. Some have even supposed that such objects may have been used by the poorer classes within the historic period, of which the paintings and sculptures in the tombs give us such vivid glimpses. The opening of an hotel at Luxor, in Upper Egypt, the site of ancient "hundred-gated" Thebes, in the winter of 1878, gave me an opportunity of carefully studying the question on the spot. I remained seven weeks and searched the region thoroughly in various directions, so far as was possible in journeys of one day's length. The

Nile Valley here is bounded on each side by hills of Tertiary limestone on whose flanks the present surface-soil rests without any intervening Quaternary deposits. On the western or Libyan side these hills are pierced by many dry ravines, or wadys, through which the desert sands make their way down toward the cultivable strip of alluvial soil on the bank of the river. Though Upper Egypt is a rainless region, still occasionally, perhaps once in twenty years, heavy rains occur, and great torrents tear their way down these wadys into the Nile. In the bottom of such ravines, and occasionally on the elevated plateaus of the hills, I succeeded after long and toilsome searching in finding several implements of the true St. Acheul type. I also found innumerable examples of all the various objects that are commonly discovered in other countries, in which the existence of "the stone age" is considered to be established. These were axes, scrapers, piercers, knives, flakes, nuclei, etc., together with some forms that were entirely novel, and all without exception were made by the process of chipping. Although polished implements have been occasionally discovered in Egypt, I have never myself happened to find a single example. Some few objects were met with in the eastern desert; but on the Arabian side the valley is so much wider that it is almost impossible to reach the hills in one day and have any time left for searching. At Paris I showed the objects I had discovered to M. de Mortellet, curator of the prehistoric department of the great museum of St. Germain-en-Laye, under whose charge had been placed the organization of the anthropological department of the late French Exhibition. By him I was requested to place them there, where they were seen and examined by many scholars from various countries occupied with prehistoric studies, and by all they were pronounced to be true palæolithic objects. Quaternary deposits do not occur in the Nile Valley, so far as I am aware, though they have been found in various parts of the Sahara. Consequently it is only in such spots as those in which these implements were discovered, that any relics of the early man can now be met with there. If man lived in Egypt at that remote epoch, most traces of him must now lie buried under hundreds of feet of Nile mud, the product of the annual inundation of the river for countless ages. The discovery, therefore, in the Nile Valley of all the usual types of objects of "the stone age" in other countries, including those of the most remote times, would seem to furnish a sufficient reply to the objections of such as maintain that no traces of "the fossil man" have been discovered in Egypt.

A ZOÖLOGICAL ENIGMA.

By FELIX L. OSWALD, M. D.

PROFESSOR ULRICI, the modern Rosicrucian, defends spiritualism on the plea that it meets the demands of what he calls our *Wunderbedürfniss*, the propensity to indulge in wonderment, which he includes among the normal instincts of the human mind. A taste for enigmas is a primitive manifestation of the thirst for knowledge in general, and thus akin to the very *primum mobile* of all intellectual progress, but in its legitimate forms that propensity might exert its functions on an ample field within the domain of the strictly physical sciences. The problems of modern chemistry, physiology, and natural history confront us with countless unsolved questions, with phenomena more wonderful in their reality than any dreams of hysterical hallucinations or of the wildest fancy. The marvel-hunter who gropes his way through the arcana of an unknown world might pursue his quarry more profitably on the hunting-grounds of his own planet—more successfully, too, if he would keep his eyes open. The sunlit fields and the gaslit laboratory reveal truer wonders than the dark closet of the spook-manufacturer ; the tests of the naturalist yield the same result at all times and under all circumstances—their success does not depend on the obfuscation of the locality (and of the witnesses) ; it is not jeopardized by the presence of skeptical critics, or the absence of discreet accomplices. Many notorious phenomena, apparently familiarized by their frequency, in reality still involve mysteries whose solution might disclose new paths of research, or reflect a helpful light upon the problems of a kindred science. The diffusion of contagious diseases, submarine currents, the synchronism of storms and shooting-stars, hibernation, the survival of reptiles in close-grained rocks, the weather-wisdom of the tree-toad and trap-door spider, for instance, have been only partially explained ; nay, every amateur naturalist may indulge in an experiment whose general result seems so utterly inexplicable on any recognized scientific principle that it reduces our speculations to a phraseology of metaphors—to the nomenclature of an unknown quantity.

We often hear of the wondrous sagacity—generally ascribed to memory or acuteness of scent—which enables a dog to find his way home by unknown roads, even from a considerable distance. I think it can be practically demonstrated that this faculty has nothing to do with memory, and very little with *scent*, except in a quite novel sense of the word.

Last fall, my neighbor, Dr. L. G——, of Cincinnati, Ohio, exchanged some suburban property for a house and office near the City Hospital, and at the same time discharged a number of his four-footed retainers. A litter of poodle puppies were banished to Covington, Kentucky, across

the river, and two English pointers were adopted by a venatorial ruralist in the eastern part of Ohio. The puppies submitted to exile, but one of the pointers, like the black friar in the halls of Amundeville, declined to be driven away. He returned, by ways and means known to himself alone, once from Portsmouth and twice from Lucasville in Scioto County, the last time in a blinding snow-storm and under circumstances which led his owner to believe that he must have steered by memory rather than by scent. But how had he managed it the first time? The matter was discussed at a reunion of sportsmen and amateur naturalists, and one opponent of the doctor's theory proposed as a crucial test that the dog be chloroformed, and sent by a *night-train* to a certain farm near Somerset, Kentucky (one hundred and sixty miles from Cincinnati): if he found his way back, he could not have done it by memory.

The doctor objected to chloroform, remembering that dogs and cats often forget to awake from anæsthetic slumbers; but finally Hector was drugged with a dose of Becker's elixir (an alcoholic solution of morphine), and sent to Somerset in charge of a freight-train conductor. The conductor reports that his passenger groaned in his stupor "like a Christian in a whisky-fit"; at length relieved himself by retching, and went to sleep again. But in the twilight of the next morning, while the train was taking in wood at King's Mountain, eighteen miles north of Somerset, the dog escaped from the caboose and staggered toward the depot in a dazed sort of way. Two brakemen started in pursuit, but, seeing them come, the dog gathered himself up, bolted across a pasture, and disappeared in the morning mist. At 10 A. M. on the following day he turned up in Cincinnati, having run a distance of one hundred and forty-two miles in about twenty-eight hours.

Still the test was not decisive. The dog might have recovered from his lethargy in time to ascertain the general direction of his journey, and returned to the northern terminus by simply following the railroad-track backward. The projector of the experiment, therefore, proposed a new test with different amendments, to be tried on his next hunting-trip to central Kentucky. On the last day of January the dog was sent across the river, and, *nem. con.*, the experimenter fuddled him with ether, and put him in a wicker basket, after bandaging his nose with a rag that had been scented with a musky perfume. Starting with an evening train of the Cincinnati Southern Railroad, he took his patient southwest to Danville Junction, thence east to Crab Orchard, and finally northeast to a hunting rendezvous near Berea in Madison County. Here the much-traveled quadruped was treated to a handsome supper, but had to pass the night in a dark tool-shed. The next morning they lugged him out to a clearing behind the farm, and slipped his leash on top of a grassy knob, at some distance from the next larger wood. The dog cringed and fawned at the feet of his

traveling companion, as if to conciliate his consent to the meditated enterprise, and then slunk off into a ravine, scrambled up the opposite bank and scampered away at a trot first, and by and by at a gallop—not toward Crab Orchard, i. e., southeast, but due north, toward Morgan's Ridge and Boonsboro—in a bee-line to Cincinnati, Ohio. They saw him cross a stubble-field, not a bit like an animal that has lost its way and has to turn left and right to look for landmarks, but, "like a horse on a tramway," straight ahead, with his nose well up, as if he were following an air-line toward a visible goal. He made a short *détour* to the left, to avoid a lateral ravine, but farther up he resumed his original course, leaped a rail-fence, and went headlong into a coppice of cedar-bushes, where they finally lost sight of him.

A report to the above effect, duly countersigned by the Berea witnesses, reached the dog's owner on February 4th, and on the afternoon of the following day Hector met his master on the street, wet and full of burrs and remorse, evidently ashamed of his tardiness. That settled the memory question. Till they reached Crab Orchard the dog had been under the full influence of ether, and the last thing he could possibly know from memory was a *misleading* fact, viz., that they had brought him from a southwesterly direction. Between Berea and Cincinnati he had to cross two broad rivers and three steep mountain-ranges, and had to pass by or through five good-sized towns, the centers of a network of bewildering roads and by-roads. He had never been in that part of Kentucky before, nor ever within sixty miles of Berea. The inclination of the watershed might have guided him to the Kentucky River, and by and by back to the Ohio, but far below Cincinnati and by an exhaustingly circuitous route. The weather, after a few days of warm rains, had turned clear and cool, so that no thermal data could have suggested the fact that he was two degrees south of his home. The wind, on that morning, varied from west to northwest; and, if it wafted a taint of city atmosphere across the Kentucky River Mountains, it must have been from the direction of Frankfort or Louisville. So, what induced the dog to start due north?

"Instinct." Of course, but the demands of science are not to be satisfied with conventional phrases. Blind instincts we may call such feelings as hunger, the craving after fresh air, and other promptings of our internal organs; also, perhaps, the faculty of executing such uniform mechanical functions as the construction of an hexagonal cell or of a spheroid cocoon; but, if such faculties have to adapt themselves to variable and uncertain circumstances, they require the aid of a sense—i. e., of a *discriminative* organ. So the question comes back upon us, What sense aided the dog in the choice of his direction? Scent? It seems too impossible, though the assumption of a "sixth sense" would be the only alternative. A blind man finds his way through the mazes of a city, or an intricate system of halls and corri-

dors, by what we might call locomotive memory—i. e., the faculty to remember a long series of turns in their due sequence and with the correct intervals of time or space. The sense of touch becomes here vicarious to eyesight. In the same way a wide-awake animal might take cognizance of certain locomotive data without the assistance of its eyes. It might *feel* the turnings of its rolling cage, and remember enough to imply the general direction. A stupefied animal could not do it. The olfactory power of a dog exceeds ours about as much as human eyesight exceeds that of a shrew-mouse. A dog will "set" a covey of partridges across a broad field, and can scent a tramp from a distance of half a mile. A nose that can track the faint scent of a rabbit through thickets of aromatic herbage might easily distinguish the atmosphere of a reeking manufacturing town at a distance of ten miles. At fifty miles it might be barely possible under the most favorable conditions of wind and weather; at one hundred and fifty miles it seems impossible under all circumstances. Besides, a dog would find his way to a backwoods cabin as readily as to a smoky metropolis. The question still recurs: How does he manage it? Should dogs be gifted with the faculty of determining geographical latitude and longitude by means of their noses?

The memory-hypothesis being disposed of, the scent-theory might be definitely settled by a simple operation, viz., destruction of the olfactory nerve. Any anatomist could do it. Helmholtz and Von Graefe made similar experiments with the optic nerve, even without inflicting permanent damage. A dog might be rendered scentless for a day or two, and a trip to the next county under the above-described collateral precautions would decide the point. Deerhounds, pointers, and terriers would be the best subjects for the experiment; greyhounds are not only inferior in acuteness of scent but in sagacity in general; and collies and poodles, though marvelously clever in their peculiar spheres, seem to be almost destitute of what the French call the *sens d'orientation* (the sense of *orientation*—the process of determining the points of the compass).

Leaving the exegetical question out of view, I will here venture a conjecture in regard to the origin, or rather the original purpose, of the strange faculty. The common ancestor of all domestic dogs was probably some near relative of the *Canis lupus*, either the dog-wolf of the Hindoo-Koosh, or the *Canis aureus*, the Indian or African jackal. The puppies of all these canines are born in litters—from six to ten at a time, are helpless for the first ten weeks, and entail a great amount of trouble on their food-purveyors. The mother, perhaps straitened in her own means of support, has now to meet the demands of a greatly enlarged household, and in all probability the available supplies of animal food in her next neighborhood will soon be exhausted. Her forage excursions must be extended to greater and greater distances, in a barren country like northern Africa or Turkis-

tan perhaps to remote oases and mountain-regions, hundreds of miles away. She-wolves that must have come from Lithuania or eastern Poland have been shot in northern Germany. Under such circumstances topographical instinct becomes a matter of vital importance, and where there is a want Nature always finds the means of supplying it. All our senses are comparatively rudimental. Every organ holds the possibility of an infinite functional development. In man the ability of distinguishing black from white has been perfected into the art of reading, the faculty of identifying at a single glance half a hundred multiform black marks on a white background. By constant practice and hereditary transmission of cumulative acquirements, the ability of remembering the bifurcation of a ravine, or of smelling a muskrat across a creek, was thus, perhaps, developed into the art of recollecting the ramifications of a vast mountain system or of scenting the atmosphere of a given locality athwart a continent.

Similar causes have produced similar results in other species of animals, for the sense of orientation is not confined to the genus *Canis*. Horses and goats show traces of the same talent; pigeons, crows, falcons, and all migratory birds possess it in a transcendent degree; also all migratory fishes and reptiles, shad, sturgeons, tunnyfish, and marine tortoises. Now, there is no doubt that in most birds the olfactory sense is very feebly developed. Eagles, falcons, and sparrow-hawks hunt by sight, and even condors and other vultures have been decoyed with sham carcasses, hides stuffed with straw or stones. Pigeons and chickens are very sharp-sighted and awaken at the slightest sound, but a noiseless thief can surprise them in any dark night—the sense of smell does not warn them. Von Haller went so far as to assert that birds can not smell at all, and that their nostrils are only respiratory apertures.

How, then, could carrier-pigeons find their way from Cleveland to Philadelphia? Belgian pigeons have carried letters from Paris to Namur and from Geneva to Brussels, in fourteen and twenty-two hours; and a gerfalcon, which Henri Quatre presented to the commander of a Mediterranean brigantine, returned from Tangier to Paris in a single day. Did they steer by sight? However telescopic their vision might be, the incurvation of the globe would preclude the idea.

The bird-of-passage instinct is much less wonderful. Cranes and geese might steer due south by the aid of the noontide sun, and return by inverting the process till they come in sight of familiar scenery. A Northampton swallow, flying at the rate of two miles a minute, could well afford to roam at random over the State of Massachusetts till she came in sight of the Holyoke range and Mount Tom. A sturgeon, too, might find his spawning-grounds at the mouth of the Ottawa by following the St. Lawrence upward till he reached the Chaudière of St. Anne. In short, the art of retracing a self-chosen route appears much less enigmatical. But even reptiles have crossed

unknown seas by the aid of the same geographical second-sight which guided the Philadelphia pigeons to their native roost. According to a well-authenticated report, the crew of a British East Indiaman caught an enormous tortoise near St. Helena, marked it with the brand of the company, and quartered it in the cockpit, but in the English Channel their captive crawled on deck and plunged overboard. Two years after, the same tortoise was caught in Sandy Bay near Jamestown, on the south coast of St. Helena. No ocean-current could have carried it there; it must have navigated by its inner compass a distance of seven thousand English miles.

Should the occult sense be merely an unknown function of a well-known organ? A person whose eyesight is limited to the range of his ear-shot would fail to comprehend how an earthly being could see stars beyond the boundaries of the solar system, and a nation of mole-eyed men would speak of the *instinct* that enables a *homo* of a different species to reach a distant village by keeping his eye on the steeple. We may have a dormant rudiment of that same sixth sense. Perhaps it awakens in the pulmonary beatitude that expands our chests in the atmosphere of a sunlit forest, or in the nausea induced by the effluvium of a stagnant bayou. Neither sensation is necessarily dependent on the olfactory sense.

We have lost several faculties from sheer disuse, but it is not probable that their number includes the instinct of orientation. It is deficient in many of our fellow creatures, both of the higher and lower orders. Monkeys, sheep, black cattle, gallinaceous birds, lizards, and lepidopterous insects seem to be almost devoid of it. Should we not be able to detect some characteristic structural difference between monkeys, chickens, and lizards on the one hand, and dogs, pigeons, and tortoises on the other? A peculiar instinct must correspond to some peculiar organization, and I think that specialty could be determined in the domestic dog if anywhere. For many reasons the *modus operandi* of a function can be more easily observed in a docile mammal than in a reptile or a shy bird, and, if we hope to force the intrenchments of the enigma, we had better "fight it out on this line." If one of the five senses should be the functional medium of the strange instinct, there must be ways and means to identify it; if there is such a thing as a sixth sense, we should be able to locate its organ. The "intuitive cerebration" theory is untenable. In the well-known axiom that nothing comes within the ken of our intellect but what has entered by the gate of the senses, we may confidently substitute "intuition" for "intellect." In other words, we have few reasons to doubt and many reasons to suspect that every psychic emotion, as well as perception, is the reflex of some organic impression.

ON THE MODES OF DISTRIBUTION OF PLANTS.

By JOSEPH F. JAMES.

THE study of the geographical distribution of plants over the earth is one of the most profound interest, not only to the botanist but to mankind in general. To the former it is of especial interest on account of the intimate relations existing between it and the origin of the different species of plants. Where we find an isolated example of a group of plants existing in one country, while its nearest congeners are in another perhaps thousands of miles off, we naturally feel interested in trying to discover the cause of this wide separation, and the means by which the plant has reached its present location. It is to the means of distribution that we shall devote this paper.

It is a trite remark that although there may be places identical in temperature, in soil, in humidity, and other circumstances governing the stations of plants in both North America and Europe, and in South America and Africa, still it does not necessarily follow that the species of plants in these identical localities are alike or even at all similar. Indeed, researches show it to be rarely or never the case. In almost every country, however, there seems to be a certain though sometimes a small proportion of plants which are found in other and distant parts of the world. For instance, Mr. Brown found that, out of 4,100 species of plants then known to inhabit Australia, 166 were identical with those of Europe, and that the greater proportion of these were cryptogamous plants, while those that were not were plants common to the intervening regions.* There are 359 indigenous plants out of the 2,277 phænogams given in the last edition of Gray's "Manual," which are also indigenous to Europe. A number, too, of the plants of eastern North America are common to northeastern Asia, China, Japan, and India. Out of a collection of 600 plants from the river Congo in Africa, Dr. R. Brown found thirteen which also grew on the opposite coasts of Brazil and British Guiana.† No less than one fifth of the algæ from the Antarctic seas, exclusive of the New Zealand and Tasmanian groups, have been identified by Dr. Hooker with British species.‡ A few of the most remarkable cases of distribution of identical species will no doubt be of interest here. *Sauvegesia erecta* grows in the Antilles, in Brazil, in Madagascar, and in Java; *Scirpus maritimus* grows in North America, in Europe, in western India, in Senegal, at the Cape, and in Australia;§ *Brasenia peltata* grows in the United States, in Japan, in eastern India, and in

* Lyell, "Principles of Geology," ii., p. 387.
† Lyell, ibid., ii., p. 394.
‡ Lyell, ibid., ii., p. 389.
§ Jussieu, "Elements of Botany," p. 718.

Australia.* Several species of the mosses (*Funaria*, *Dicranum*, and *Bryum*) are common to the Blue Mountains of Jamaica, the Peak of Teneriffe, and Lapland.† Among 133 plants from one of the Pyrenees, Raymond found thirty-five identical with those of Melville Island in the Arctic Ocean.‡ *Potentilla anserina* grows in North America from Pennsylvania to California and northward, in the northern part of the Old World, in Chili, and in New Zealand; *Monotropa uniflora* from Canada to Louisiana, in Oregon, in New Granada (South America), and Himalaya Mountains in India; *Dichondora repens* from Virginia to Chili, in New Zealand, in Tasmania, to eastern Africa, and at the Cape of Good Hope; *Adiantum pedatum* is found in the eastern United States and Canada, to Oregon, in Kamtchatka, Japan, and Nepaul in India; *Crantzia lineata* in the United States from Massachusetts to Texas, in South America from Buenos Ayres to Falkland Islands, and in New Zealand; § *Phleum alpinum* inhabits the United States, Switzerland, and the Straits of Magellan. ‖

These few cases will suffice to show the strange and apparently capricious distribution of plants. All these are, of course, supposed to be indigenous to the various countries given as their habitats. Now, according to the theory of natural selection and of descent with modification, we must suppose that all plants have descended from parents like themselves, and have not been specially created where they are now found. When we find, therefore, two plants of the same species, or of the same genus closely allied to each other, inhabiting the United States and Europe, or Europe and New Zealand, we must naturally suppose that at some time or other they had descended from the same kind of an ancestor, but that owing to circumstances they have become widely separated. Plants are not like animals, endowed with locomotive organs, and they must therefore have depended on the elements to transport them. To try and discover these modes of transport, then, we shall now proceed.

The winds undoubtedly exercise an immense influence on the distribution of plants. Many seeds are furnished with a pappus or feathery appendage, by means of which they are easily carried along by the wind. Many of these belong to the *Compositæ*, such as the dandelion, the thistles, hieraciums, etc. Others are provided with wings, as in the ash and the maple; still others with cottony or feathery tails, as in the anemones and clematis. Again, many are so minute as to be visible to the eye only in the form of smoke, and are so numerous as to be almost uncountable. This is especially the case with fungi, mosses,

* Gray's "Manual of Botany," p. 55.

† Humboldt's "Travels," i., p. 115.

‡ Jussieu, *loc. cit.*, p. 712.

§ These five and many others are noticed in an article by Professor Asa Gray, in "Silliman's Journal," second series, vol. xxiii., p. 381, *et seq.*

‖ Humboldt, *loc. cit.*, i., p. 423.

lichens, and ferns. The spores of fungi are so minute as to require a microscope to see them, and so numerous that Fries says he counted in a single specimen of *Reticularia maxima* no less than 10,000,000.* What wonder, then, that with seeds so minute and so numerous these plants should be almost universally distributed? Out of 200 lichens, for instance, brought home to England by the Antarctic Expedition under Sir James Ross, almost every one has been ascertained to be also an inhabitant of the northern hemisphere, and most of them of Europe. It is easy enough to imagine the wind capable of transporting minute spores to immense distances over land and ocean. Many plants not possessing small seeds are carried off bodily by the wind to distant localities. Of these there is the "leap-in-the-field," or the "wind-witch," inhabiting the steppes of southern Russia. "A poor thistle-plant," says Schleiden, "it divides its strength in the formation of numerous dry slender shoots, which spread out on all sides, and are entangled with one another. . . . The domes which it forms upon the turf are often three feet high and sometimes ten to fifteen in circumference, arched over with naked, delicate, thin branches. In the autumn the stem of the plant rots off, and the globe of branches dries up into a ball light as a feather, which is then driven through the air by the autumnal winds over the steppe. Numbers of such balls often fly at once over the plain with such rapidity that no horseman can catch them; now hopping with short, quick springs along the ground, now whirling in great circles round each other, rolling onward in a spirit-like dance over the turf, now caught by an eddy, rising suddenly a hundred feet in the air; often one 'wind-witch' hooks on to another, twenty more join company, and the whole gigantic yet airy mass rolls away before the piping east wind."

Still another plant, the so-called "rose of Jericho," but really one of the *Cruciferæ*, has a similar method of dissemination. Professor Lindley says of it: "At the end of its life, and in consequence of drought, its texture becomes almost woody, its branches curve up into a sort of ball, the valves of its pods are closed, and the plant holds to the soil by nothing but a root without fibers. In this state the wind, always so powerful on plains of sand, tears up the dry ball and rolls it upon the desert. If in the course of its violent transmission the ball is thrown upon a pool of water, the humidity is promptly absorbed by the woody tissue, the branches unfold, and the seed-vessels open; the seeds, which, if they had been dropped upon the dry sand, would never have germinated, sow themselves naturally in the moist soil where they are sure to be developed, and the young plants will be certain of nourishment. Specimens of this curious production are sometimes brought from Palestine, and, although they may be many years old, will, if placed in water, start, as it were, from their slumbers, and assume all the appearance of plants suddenly raised from the dead." The *Sela-*

* Quoted from Lindley by Lyell, "Principles of Geology," vol. ii., p. 390.

ginella convoluta, one of the *Lycopodiaceæ*, and a native of South America, has the same strange habit; for, when the ground where it grows becomes parched and dried up, it curls itself up in a ball, loosens itself from the earth, and is then whirled along over the ground by the wind. When it reaches a place suitable for its growth it uncurls itself, takes root, and flourishes till its new home dries up, when it betakes itself in the same manner to a new locality.

The brief but violent hurricanes of the tropics, which sweep over the land, uprooting trees, overturning houses, and leaving death and desolation behind them, would contribute greatly to a wide dispersion of seeds which would otherwise be but slightly distributed. The tornadoes and cyclones which not infrequently visit the temperate parts of North America would also act a part in this work. An account given by Humboldt shows a possible means of transport over high hills or even mountains. He says "M. Boussingault and Don Mariano de Rivero saw in the middle of the day, about noon, whitish, shining bodies rise from the valley of Caracas, to the summit of the Scilla, five thousand seven hundred and fifty-five feet high, and then sink down toward the neighboring seacoast. The movements continued uninterruptedly for the space of an hour, and the objects, which were at first taken for a flock of small birds, proved to be small agglomerations of straw or blades of grass. Boussingault sent me some of the straws, which were immediately recognized by Professor Kunth for a species of Vilfa (*V. tenacissima*), a grass which, together with Agrostis, is very abundant in the provinces of Caracas and Cumana."*

Let us now turn to another method of transport. As we have seen that, as a general thing, only light seeds, or those with a feathery appendage, are capable of being distributed by the wind, so we shall find that the ones dispersed by means of ocean-currents are of an entirely different character. This must necessarily be the case; for those capable of resisting the action of sea-water for a long time must be inclosed in hard shells. The Gulf Stream, that river of the ocean, is of great use in this work. By its means, seeds of *Entada scandens*, and other plants of the West Indies and tropical America, are annually thrown upon the shores of Ireland, Scotland, Norway, and even as far north as Spitzbergen. That many of these seeds would be capable of germinating, and of continuing to thrive if the climate were suitable, there can be no doubt. A plant of *Guilandina bonduc*, one of the *Leguminosæ*, was raised from a seed cast on the west coast of Ireland. Logs of wood and bodies of Indians, which had been conveyed by ocean-currents from the West Indies, have been cast on the shores of the Azores and Madeira Islands. A *Sapindus saponaria*, the common soap-berry tree of the West Indies, was raised from a seed found on the south shore of one of the Bermuda Islands.† The fact already noticed, of some of the plants on the coast of Brazil and British Guiana being

* "Aspects of Nature," p. 247. † Jones, "Naturalist in the Bermudas," p. 190.

identical with some from the banks of the lower Congo, can be accounted for on the supposition that the seeds were carried from one place to the other by an ocean-current. This becomes still more reasonable when we find that the equatorial current of the Atlantic sweeps up the west coast of Africa until after it has passed the mouth of the Congo, and then crosses the Atlantic to the coast of Brazil. We find, also, that the seeds of all these plants, common to both coasts, are incased in hard coverings, and are the ones of all others capable of resisting the action of the sea-water.

The many islands of the Pacific Ocean have undoubtedly been planted with the cocoanut-palm by ocean-currents. Growing as it does in close proximity to the shore, and thriving on salt and salt water, the nuts could be easily carried out on the ocean by the tide, and then be drifted miles away from the place of growth.

Mr. Darwin found that, out of eighty-seven kinds of seeds, sixty-four germinated after an immersion of twenty-eight days, and a few survived an immersion in salt water of one hundred and thirty-seven days.* He found that ripe hazel-nuts sank immediately, but that when dried they floated for ninety days and then germinated; an asparagus-plant with ripe berries floated for twenty-three days, and when dry for eighty-five days, and the seeds when planted germinated. Altogether, out of ninety-four plants, eighteen floated for above twenty-eight days, and some of the eighteen for a much longer period.† Estimating the average rate of the several Atlantic currents at thirty-three miles a day, Darwin came to the conclusion that seeds of one tenth of the plants of a flora, after being dried, could be floated across a space of sea nine hundred miles wide, and would then, if driven to a favorable locality, be capable of germination.‡ Seeds have sometimes been found lodged in trees completely protected from contact with the atmosphere. Rocks are known to be lodged in roots of trees, and these, floating on the ocean, are often drifted to islands, and the rocks taken out by the natives. Mr. Darwin thinks that seeds could often effect a lodgment in the crevices with these stones and thus be conveyed long distances.§

Captain Mitchell says he passed through a mass of sea-weed, etc., twelve to fourteen miles across, when three hundred miles from the mouth of the Gambia, which, as Dr. Dickie, who noticed the fact, believed, had come from some part of America within the influence of the Gulf Stream. "Besides algæ," says Mr. Bentham, whom we quote, "the portions of this mass picked up by Captain Mitchell and examined by Dr. Dickie contained, among other substances, fruits, seeds, and 'seedling plants several inches long, all with a pair of cotyledons, roots, and terminal bud, quite fresh.'"‖ Even if, as is sug-

* Darwin, "Origin of Species," chapter xii, p. 324. † Ibid., p. 325.

‡ Ibid., p. 326. § Ibid., p. 326.

‖ Address by Mr. Bentham before the Linnæan Society. "Nature," vol. vi., p. 131.

gested in the article quoted, the mass had come from some African instead of an American river, it still shows one means by which seeds could be dispersed. Wallace gives further confirmation of this fact. He says: "Rafts of islands are sometimes seen drifting a hundred miles from the mouth of the Ganges, with living trees growing on them, and the Amazon, Orinoco, Mississippi, Congo, and most great rivers produce similar rafts. Spix and Martins declare that they saw at different times, on the Amazon, monkeys, tiger-cats, and squirrels being thus carried down the stream. . . . Admiral Smyth informed Sir Charles Lyell that among the Philippine Islands after a hurricane he met with floating masses of wood with trees growing upon them, so that they were at first mistaken for islands, till it was found that they were rapidly drifting along. . . . The fact of green trees so often having been seen erect on these rafts is most important; for they would act as a sail by which the raft might be impelled in one direction for several days in succession, and thus at last reach a shore to which a current alone could never have carried it."* Now, if such rafts as these were capable of conveying large animals, it would be extremely probable that they would also have on them seeds of many kinds of plants; and, as we shall see hereafter, as the animals themselves often convey unintentionally seeds sticking to their coats, they too would be vehicles for their transportation.

Besides the rafts floated down the rivers, it is very probable that those which overflow their banks periodically, as the Nile, the Ganges, Amazon, Orinoco, and Mississippi, or occasionally as many other rivers do, would transport seeds from plants growing at their sources to hundreds of miles below. Darwin gives the details of an experiment he tried, which illustrates in a remarkable manner the extent to which the mud of rivers and ponds is charged with seeds waiting for a chance to develop. He says: "I took, in February, three tablespoonfuls of mud from three different points beneath water on the edge of a little pond; this mud when dried weighed only six and three fourths ounces. I kept it covered up in my study for six months, pulling up and counting each plant as it grew; the plants were of many kinds, and were altogether five hundred and thirty-seven in number; and yet the viscid mud was all contained in a breakfast-cup!"† There can be no doubt whatever that, after inundations of the land by the rivers, plants spring up in localities where they were unknown before, and the inference is just that the seeds were conveyed by the water.

Birds, too, furnish another and important means of transport. Many fruits having a seed incased in a hard shell are surrounded by a juicy pulp: such are the cherry, plum, mistletoe-berry, hawthorn, etc. All these are eaten by birds which, assimilating the pulp, cast the stones in their excrement. The parasitic mistletoe has no way of

* Wallace "Geographical Distribution of Animals," vol. i., pp. 14, 15.

† "Origin of Species," pp. 345, 346.

being disseminated but by the birds; these, swallowing the berries, use the pulp and cast the stone on branches of trees with bark suitable for their growth, where they take root and flourish. That the vitality of many seeds is not at all impaired by this process of passing through the stomachs of birds has been incontestably proved. Indeed, it is said that, when the farmers of some parts of England are desirous of making a hedge of hawthorn (*Cratægus oxyocantha*) grow in a short time, they feed the haws to their turkeys; the stones are rejected in the excrement, and when collected and planted a whole year is gained in the growth of the plant.* It is also known by experiments that seeds in the crops of birds are not always injured; for the crop does not secrete gastric juice, and, as it is often not until twelve or eighteen hours after the act of swallowing that the food passes into the stomach, birds which are capable of rapid and prolonged flight could pass over a large tract of land or of sea. Passenger pigeons have been killed in the neighborhood of New York with their crops still full of rice collected by them in the rice-fields of Georgia and Carolina. As it is positively asserted that they will decompose food in less than twelve hours, they must have traveled three or four hundred miles in less than six hours.† This is by no means an extravagant estimate, but rather under the mark. Falcons are reckoned the swiftest of all birds. It is recorded that one, sent from the Canaries to Spain, returned to the Peak of Teneriffe in six hours, a distance of about seven hundred and eighty miles.‡ Seeds of wheat, oats, millet, Canary hemp, clover, and beet, germinated after being twelve to twenty-one hours in the stomach of birds of prey; and two seeds of beet germinated after having been thus retained for two days and fourteen hours.§ Seeds taken out of the crop of a pigeon, which had floated on artificial sea-water for thirty days, nearly all germinated.‖ Hawks are always on the lookout for weary birds, those which have made long journeys; and pigeons and ducks coming from over the sea, as they are often known to do, would be easily caught and devoured by these birds. The bodies are devoured, and the contents of the crop perhaps scattered in a locality favorable to the development of any seeds which might be contained therein. Darwin forced seeds of various kinds into the stomachs of dead fish which were then given to eagles, storks, and pelicans. These birds, after an interval of many hours, passed the seeds in their excrement, or else rejected them in pellets, and several of them were then capable of germination. Some kinds, however, were invariably killed by the process.¶

Besides this method there is still another. This is by means of dirt or dried mud adhering to the legs and feet of birds. Still drawing on that cyclopædia of learning, Darwin's "Origin of Species," we read:**

* Lyell, "Principles of Geology," vol. ii., p. 398.
† Audubon.
‡ Figuier, "Reptiles and Birds," p. 193.
§ Darwin, *loc. cit.*, p. 327.
‖ Darwin, p. 326.
¶ Darwin, ibid., p. 327.
** P. 328.

"Although the beaks and feet of birds are generally clean, earth sometimes adheres to them. In one case I removed sixty-one grains, and in another case twenty-two grains, of dry argillaceous earth from the foot of a partridge, and in the earth there was a pebble as large as the seed of a vetch. Here is a better case: the leg of a woodcock was sent me by a friend, with a little cake of dry earth attached to the shank weighing only nine grains, and this contained a seed of the toad-rush (*Juncus bufonis*), which germinated and flowered. . . . Professor Newton sent me the leg of a red-legged partridge (*Caccabis rufa*), which had been wounded and could not fly, with a ball of earth adhering to it weighing six and a half ounces. The earth had been kept for three years, but, when broken, watered, and placed under a bell-glass, no less than eighty-two plants sprang from it; these consisted of twelve monocotyledons, including the common oat and at least one kind of grass, and of seventy dicotyledons which consisted, judging from the young leaves, of at least three distinct species. With such facts before us, can we doubt that the many birds which are annually blown by gales across great spaces of ocean, and which annually migrate—for instance, the millions of quail across the Mediterranean—must occasionally transport a few seeds in dirt adhering to their feet or beaks?"

So, too, animals perform a part in this grand work. Many seeds are furnished with hooks or prickles of various kinds, which enable them to cling to the hair and wool of animals. Take Lyell's illustration of the hunted deer as an instance of how this work could be performed: "A deer has strayed from the herd when browsing on some rich pasture, when suddenly he is alarmed by the approach of his foe. He instantly takes to flight, darting through many a thicket and swimming across many a river and lake. The seeds of the herbs and shrubs which have adhered to his smoking flanks, and even many a thorny spray which has been torn off and fixed itself in his hairy coat, are brushed off again in other thickets and copses. Even on the spot where the victim is devoured, many of the seeds which he has swallowed immediately before the chase may be left on the ground uninjured and ready to spring up in a new soil."*

As Lyell remarks in this quotation, many of the seeds which animals swallow may pass through the stomach and still retain vitality enough to sprout after being left on the ground. Instances of this can be seen in almost every barnyard, where the grains of corn and oats dropped in the excrement of cows and horses sprout, if not picked up by the barnyard fowls. Farmers know well, too, that a field manured with fresh manure is likely to produce not a few weeds along with its legitimate crop.

Even such insignificant forms of life as insects may and do perform a part in the transportation of seeds. From a small packet of

* "Principles of Geology," vol. ii., p. 397.

locusts' dung received from South Africa, Mr. Darwin extracted and raised seeds of seven grass-plants, which belonged to two species of two genera.* These locusts are sometimes found as far as three hundred and seventy miles from land; and an account is given of a cloud which hovered round the Island of Madeira for three days, and then disappeared without alighting. Such a cloud as this would undoubtedly be capable of introducing the seeds of foreign plants into insulated localities. The immense number of grasshoppers which have devastated the plains of Kansas and Nebraska would in the same way be the means of introducing seeds of foreign plants.

There is still another method which has been at times used by Nature for the distribution of plants, and that is by means of the alternation of hot and cold epochs, commonly known as glacial periods. Now, it has been demonstrated beyond all doubt that at one period of the earth's history the Arctic regions were much warmer than they are at present; this is proved by the occurrence in the geological formations of these high northern latitudes of plants in a fossilized state, which were utterly incapable of existing in any latitude where the climate was colder than it is now in our temperate regions. Reasoning from analogy and our knowledge of the present distribution of Arctic plants, it would not be improbable that the plants inhabiting the lands of the pole were the same on all longitudes of the Arctic Circle. Let us, then, suppose the glacial period to commence in these warm lands. Each plant, following to a greater or less degree the longitudinal line on which it grew, would be slowly but steadily driven by the increasing cold to take refuge in warmer and more southern stations. The cold, in the course of years following them slowly up, would compel them to keep continuing their journey southward until such time as the maximum of cold had been reached. Then, if, as it is reasonable to suppose, many of these plants had migrated on the longitudinal line upon which they had lived directly southward, we would find that the plants, which at the Arctic Circle, or beyond, had lived in close proximity to each other, would be separated when they reached the temperate zone by hundreds of miles.

In the general journey southward, the plants of the mountains would descend to the plains and mingle with those of the far north. Then the climate commences to moderate; and, as the mountains of ice and snow retire to their original homes in the north, many of the plants would keep company with the cold and return, but many others, encountering mountains in their paths, would find the climate cold enough for their growth, and would be left there in isolation while their nearest relatives would be separated from them by hundreds of miles of country.

Now would come the cold period of the southern hemisphere and drive the plants inhabiting the country there northward, and these again

* "Origin of Species," p. 327

would retire south or up the mountains of the tropics when the cold moderated and the warm season again commenced. Then another season of glacial cold begins in the north. The plants which had before been left on the mountains would stand a good chance of being driven by the increasing cold to the plains, and still farther south, even perhaps across the equator into the southern hemisphere, and when the cold again decreased would retire to the fastnesses of the mountains.

If we accept this view of the influence of glacial periods on the vegetable kingdom, we shall see that many of the apparently anomalous cases of distribution mentioned in the first part of this article are explained. We can easily see why some of the inhabitants of the temperate and arctic zones of the northern are represented in corresponding zones in the southern hemisphere; it is easily explained why identical species of mosses are found in Lapland, on mountains of Jamaica, and the Peak of Teneriffe; why plants of the Pyrenees are identical with those of the Arctic regions; why species are found on the White Mountains of New Hampshire and in Greenland, but not in the intervening region, and why species are found in northern Europe and America, in Chili and New Zealand. This theory of alternate hot and cold periods is as yet the only one by means of which these cases can be explained.

Such, then, are some of the natural methods for the distribution of plants; the air, the water, beasts, birds, and fishes, as we have shown, all perform their several offices; but there is still another method of transport of which nothing has been said, and this is the part which man plays in the grand work. This is by no means insignificant, and can be shown in many ways. Out of the 2,582 species given in Gray's "Manual of Botany", there are 305 introduced species, and, of these, 278, all but 27, were imported from Europe. Nothing shows more strikingly man's influence than this fact, which is further corroborated by the assertion that the greater part of the plants naturalized at the Cape of Good Hope and in Australia are of European origin.* With the great increase of facilities for travel, on land and on sea, with the extension of commerce to all quarters of the globe, and with the settlement and consequent clearing off of formerly unoccupied lands, we find both the fauna and flora of many countries greatly modified. There can be no more striking example of this influence of mankind then that shown in the Island of St. Helena. "When St. Helena was discovered, about the year 1506," says Lyell,† "it was entirely covered with forests, the trees drooping over the tremendous precipices that overhang the sea. Now, says Dr. Hooker, all is changed; fully five sixths of the island is entirely barren, and by far the greater part of the vegetation which exists, whether herbs, shrubs, or trees, consists of introduced European, American, African, and Australian plants, which propagated themselves with such rapidity that the native plants could not compete with them.

* Lyell, "Principles of Geology," vol. ii., p. 402. † Lyell, ibid., vol. ii., p. 457.

These exotic species, together with the goats, which, being carried to the island, destroyed the forests by devouring all the young plants, are supposed to have utterly annihilated about one hundred peculiar and indigenous species, all record of which is lost to science, except those of which specimens were collected by the late Dr. Burchell, and are now in the herbarium at Kew."

Dr. Burchell himself sowed on a point of this island, in 1845, seeds of *Chenopodium ambrosioides*, and it multiplied so rapidly that, in four years, it became one of the commonest weeds on the island, and has maintained its ground ever since.* *Erigeron Canadense*, introduced from America into Europe, has become there one of the commonest weeds, and is now naturalized all over the country.† *Datura stramonium*, now known over almost all Europe and North America, was introduced from the East Indies by the gypsies, who used the seeds as a medicine.‡ *Œnothera biennis*, introduced from America into Europe by the French, on account of its esculent roots, in 1674, has since spread so that it now grows wild in almost every country in Europe, in the hedges and about the villages. § Our agave and *Opuntia vulgaris* have both been so extensively naturalized in the south of Europe, and they form so conspicuous a feature in the landscape that they have been noticed by many travelers and recorded as indigenous. ‖ *Anacharis Canadensis* (water-weed) was introduced into England in 1841, and spread so rapidly that it has become a nuisance by impeding navigation in rivers and canals, in spite of efforts made to eradicate it. ¶ Strange to say, nothing of the kind is complained of here in its native country. In the district of Canterbury, New Zealand, Mr. Locke Travers, writing in 1863, says *Polygonum aviculare* (common dock) and sow-thistle (*Sonchus*) grow luxuriantly; the water-cress increases in the still waters and rivers so rapidly as to threaten to choke them up entirely, and to put the inhabitants to the expense of £300 annually to keep open a single stream. Stems of this cress have been measured twelve feet long and three fourths of an inch in diameter. "In some mountain districts the white clover is displacing the native grasses; and foreign trees, such as poplars and willows, and gum-trees of Australia, are growing rapidly." **

All these plants have been introduced into the different countries by man's agency. Numbers of seeds are no doubt conveyed in the raw-hides taken from one country to another. De Candolle says he found numbers of exotic plants growing in the vicinity of a place in the south of France where the hides brought by ships were washed and cleaned. Ballast-heaps near large seaport towns are favorite places of resort for resident botanists, who there often reap rich har-

* Lyell, "Principles of Geology," ii., p. 402.
† Jussieu, "Elementary Botany," p. 717.
‡ Willd., "Botany," p. 419.
§ Willd., ibid., p. 420.
‖ Jussieu, ibid., p. 717.
¶ Lyell, *loc. cit.*, ii., pp. 401, 402.
** Lyell, *loc. cit.*, ii., p. 458.

vests of introduced plants. To show their number, witness the lists given by Mr. Isaac Martindale of those found near Philadelp and of Mr. Charles Mohr, of Alabama, of those found at Pensacola New Orleans, and other places. Wars, too, are the means of sprea plants. It is said that great numbers of new plants have been in France, in the vicinity of places where the Germans had brought forage for their horses and stacked it. Of course, many plants introduced in this way do not thrive longer than a year or two, but some of them no doubt take up their residence permanently. Man's propensity to seek out attractive plants in far-off countries, and to transplant them to his home to make his garden attractive, has been the means of the naturalization of many species. These have ample opportunity to escape into the surrounding country, and with favorable conditions to spread extensively in all directions. Seeds of many weeds are mixed with the wheat and other grains which man carries with him wherever he goes, and plants wherever he may happen to settle. Railroads are efficient agents in the work. Seeds are lodged on the platforms of the cars, are carried along by the wind created by the passing trains, and in many other ways are distributed along the track. There is an instance of the work of the railroad in the east end of Cincinnati, near Fulton, on the Little Miami Railroad. For the last two or three years there have been growing great numbers of *Euphorbia marginata*, a plant which is a native of the plains of Kansas, and which is slowly but surely working its way toward the East by means of the railroads. Eastern plants, which a number of years ago were wanted in exchange with the West, are now naturalized in the West, and *vice versa*.

HYSTERIA AND DEMONISM.*

A STUDY IN MORBID PSYCHOLOGY.

By CHARLES RICHET.

III.

THE mysterious problem of somnambulism is closely connected with the study of the demoniac affection. It is necessary to enter into some details on this subject, for we should not be able to comprehend the nature of certain epidemics of the middle ages if we were not acquainted with the different symptoms of the sleep called magnetic. Moreover, the effrontery of charlatans has mixed up so many absurdities with the real facts appertaining to this malady that it is hard for persons who have not made a special study of it to preserve a just mean between the credulity that admits

* Translated from the "Revue des Deux Mondes" by W. H. Larrabee.

T[illegible]thing, however absurd, and the skepticism that admits nothing, [illegible]even that which is true. A German physician named Mesmer arrived in Paris in 1778. Marvelous stories were told of him. He [illegible] several years before, published a curious, somewhat mystic [illegible] in which he affirmed the existence of a universal fluid, diffused in all nature, and competent to pass into the body of man. He had not yet become celebrated, but Paris, then as now a center and focus of opinion, speedily gave him a brilliant renown. He established himself in quarters in the Place Vendôme, proceeded to teach his theory of the magnetic fluid, and soon gained some pupils, among whom was a doctor named Deslon, who became associated with him. Disputes arose in course of time between the two magnetizers. Deslon was reprimanded by the faculty and excluded from its association as a charlatan.

Throngs of clients came to Mesmer. Everybody wanted to be magnetized. Mesmer could not attend to all the applicants, and employed an assistant who made the passes in his place. This was not enough, and Mesmer then invented the famous *baquet*, or magnetizing chest, by means of which thirty or forty persons could be magnetized at once. The subjects were introduced together into a large room, in the middle of which was an oaken chest, containing jars, connected with each other by metallic rods. This apparatus was inclosed in another chest, from which projected handles of iron. These were taken hold of by the persons desiring to be put under the magnetic influence. A complete silence is prevailing, when suddenly sounds of melody are heard proceeding from an adjoining room. Then, under the influence of sympathetic emotion or of irritation, a kind of nervous excitation is communicated from one to another among all those who are assisting; curious symptoms appear among the magnetized persons. First, there is languor, then drowsiness; shortly afterward, a frantic agitation, which is succeeded by contortions and convulsions. The silence is broken only by the muffled tones of the organ and the groans of the patients as they fall seized with the convulsive attack. It is easy to conceive how well-suited are such scenes to develop nervous crises in persons who are predisposed to them. The infatuation became general in Paris, and there were showers of apologies, pamphlets, songs, and caricatures on Mesmerism. It was all the fashion; the house in the Place Vendôme became too small, and Mesmer bought the Hôtel de la Bullion, Place de la Bourse. In the course of five years, from 1779 to 1784, he magnetized eight thousand persons. But the Tarpeian Rock is near the Capitol; discredit rapidly followed the general favor. Mesmer was ridiculed at the opera, was abandoned by his disciples whom he had lived upon, was insulted in the streets of Paris, and had at last, in 1785, to take refuge in Switzerland.

The learned societies were not indifferent to the pretensions of animal magnetism. The Academy of Sciences appointed a committee, of

whom Bailly (that unfortunate Bailly who was to perish on the scaffold some years later) was the reporter, to investigate them. Its conclusion was that the pretended magnetic fluid did not exist, and that the experiments and observations of Mesmer were based on nothing real. One of the members of the committee, the celebrated Laurent de Jussieu, declined to sign this report, and in a memorial, which had a considerable support of public opinion, admitted that there was a portion of truth in Mesmerism, which ought to be discovered and extracted from the juggleries, unworthy the attention of scientific men, in which it was buried.

Mesmer was not, in fact, the creator of the theory of animal magnetism. If the Marquis Armand de Puységur had not repeated his experiments, the art would not have existed, and the subjects of the *baquet* of Mesmer would have been put in the same class with the convulsionists of St. Médard. Puységur cured several sick at Poissons by touching them; then others, and still others. He gathered disciples, he wrote numerous papers, he indicated the processes that should be employed to put a subject to sleep, he described the phases of induced somnambulism, between 1785 and 1825. Experimentists, whose good faith, if not their good sense, could not be suspected, everywhere repeated his experiments; physicians and men of science occupied themselves with them and confirmed them in part. Petetin, Deleuze, Dupotet, Husson, Braid, and many other persons whose names are less familiar, developed and interpreted his ideas. Through their confused work the fact has been brought up into clear evidence, from among the absurd errors and hardly imaginable follies in which it was buried, that a nervous affection of a peculiar nature may be induced among subjects who are more or less predisposed to it. At present, all enlightened physicians recognize that somnambulism exists with symptoms which are always identical, and that it has a right to be recognized as a special form of disease. We shall try to tell in a few words what must be believed about it, remarking that we do not speak of it from hearsay, but according to facts which we have ourselves observed.

The processes by the aid of which somnambulism is induced are irregular and empirical. If the subjects are predisposed and habituated, by having had previous attacks, to be affected by that neurotic disorder, a slight disturbance of the nervous system, sometimes the most insignificant in the world, is enough. A subject who has been frequently put to sleep may be magnetized in less than half a minute. But, in dealing with a person who has never before been put under magnetic influence, the rules of the magnetizers must be followed, however ridiculous they may seem. The operator must set himself opposite the face of the subject, make a few passes with his hands before his forehead, and look at him fixedly. Very often no result will be obtained at the first sitting; but the operator will learn by

experience not to be discouraged by an apparent want of success. He should make another trial on the next day, and again on the next; but, if after about the third sitting no result is obtained, it will be time to give up the subject as intractable. Such cases are, however, rare, and generally sleep is brought on at the third sitting, if not before.

The first sign observed is a kind of torpor. The countenance loses its mobility, and becomes dull and inexpressive. The subject feels a heaviness in the limbs, and a singular torpidity which prevents him from making the least exertion. He has vague sensations of heat, cold, pricklings, and, while his hands continue motionless, he suffers jerkings of the tendons and fibrillar contractions in the muscles. His eyelids become heavy and close. With many efforts he vainly opens them, only to shut them again; the time comes at last when it is impossible to make them move. A curious spectacle is then presented of a struggle between sleepiness and the will to resist it. The will has to yield at last; the head falls stupidly on the chair; the arms become motionless, keeping the attitude they had; the face is fixed as a lifeless mask, expressing no internal feeling; the closed eyelids are moved by a few convulsive tremors; the breathing is quiet; the heart beats slowly and regularly. We might at first believe that this induced sleep is identical with ordinary sleep, but it is nothing like it, and is characterized by very different symptoms.

The fact that insensibility exists in both permits us to liken induced somnambulism in a certain degree with the demoniac attack. We may prick the skin of magnetized persons with a needle, tickle their nostrils and lips with a feather, without provoking any sign from them. Unfortunately, while anæsthesia is complete in some subjects, it is wholly wanting in others, so that we can not perceive in it a single essential characteristic symptom which will permit us to judge whether the sleep of the subject is real or assumed. For this reason, some of the physicians who have employed this criterion have been led to deny the reality of somnambulism; for, instead of finding insensibility, as they had expected, they have perceived that each pricking excited a painful feeling. In certain cases even, sensibility, instead of being diminished, is exaggerated to such a point that the slightest contact excites pain. In a word, individual differences forbid us to adduce an absolute law, and there are so many exceptions that we can not speak of a rule.

The person who is put to sleep is conscious of his condition, and we may be sure that he is really asleep if he says that he is when we ask him about it. If we then inquire as to the sensations he experiences, we will generally be assured that this sleep is quite pleasant. Many of the patients whom I have put to sleep at the Hospital B—— assured me that their pains had disappeared. They also wished to remain asleep for a long time, knowing that the wakening to their normal life would be at the same time a wakening to pain. I add that, if the con-

dition of somnambulism is not disagreeable, it is also without danger. I do not know that any accidents, either grave or light, have been noticed as consequences of it; and it is even possible that in certain cases it appeases the over-excited nervous system; but on this matter it is necessary to speak with much reserve, for decisive facts bearing on it have not yet been collected.

Let us now analyze the psychological phenomena of somnambulism. We all know what a dream is: when, tired with the labors of the day, we give up to sleep, our thoughts become confused and floating; the attention can no longer be held fixed upon any definite object; we gradually lose consciousness of the exterior world, and strange forms, the reality of which is in our conception only, impose themselves upon us. They pass and repass with marvelous facility, changing at every instant, and bewildering us with a moving and fantastic train. There are human faces with the forms of beasts, wonderful monsters, gardens, palaces, persons who had disappeared long ago, and who we thought had passed from memory. All this is in motion and passes before us, and the mind assists as a powerless spectator at a representation of which it has itself formed all the pieces. The imagination luxuriates in full license, for it is freed from the liability of being interrupted as in real scenes by the intrusion of foreign objects, forcing themselves upon attention at every instant to excite precise sensations and recall us to reality. A fact which marks the difference between somnambulism and ordinary sleep is that the dream, which is only spontaneous in ordinary sleep, may be provoked in somnambulism. It would be very hard, for example, to make a man who is sleeping quietly in his bed dream of a lion. If we should say to him aloud, "Look at the lion!" one of two things would happen: he would not hear us, or he would wake up; but in either case he would not dream of a lion. On the other hand, I once said to one of my friends whom I had put into the condition of somnambulism, "Look at that lion!" He started at once, and his face expressed fright; "He is coming," he said, "he is coming nearer, let us run away—quick, quick!" and he almost had a nervous crisis under the influence of his terror.

It is well known that the magnetizers by profession pretend to cause their subjects to travel (in mind) through space, and to make them spectators at distant scenes. This is true. But it is not true, it is rather absolutely false, that these dreams partake of the reality, that the visions bear any relation to the truth. They are pure imaginations, and are neither more nor less fanciful than all the vague conceptions which are forged by every person during sleep. By way of example, I will relate a story of one of the somnambulist patients in the Hospital B——. I said to her: "Come with me; we will go away and travel." She then described in succession the places we had to pass; the corridors of the hospital, the streets we had to go through to get to the railroad station; she arrived at the station, and, as she was ac-

quainted with all of these places, she pointed out with sufficient exactness the details of the spots which her imagination and memory, equally over-excited, represented to her under a real form. She could be instantaneously transported to a distant place she was not acquainted with, the Lake of Como, for example, or the frozen regions of the north pole. Her imagination, left to itself, indulged in descriptions which were not wanting in attractiveness, and were always interesting by their apparent precision; but no greater mistake could be made than to accord to these chimerical conceptions the honor of being truths. Having one day put a friend to sleep, I undertook to send him on a voyage by balloon to the moon. I felt a real surprise when he said to me delightedly, "Oh! oh! what is that great white ball below us?" His imagination represented the earth to him. He saw animals of fantastic shapes, and, when I told him we must take some of them to the earth, he objected: "Why," said he, "you do not know how we are going to get down, and you want to charge yourself with those great animals? I thank you, I will let you do it, and shall certainly not trouble myself with them." He was, nevertheless, aware of the strange character of his visions, and said: "What a fine story we could tell about them; but, unfortunately, they would not believe us!"

The reason of somnambulists is perhaps perverted, but their intelligence is certainly not diminished. It is over-excited and exceedingly active. Varied and engaging conversations may be held with a subject who has been put to sleep. The language of uneducated women, for example, becomes almost elegant, with ingenious turnings of phraseology, and ideas that do not lack in elevation. Without assuming in the slightest degree that they can divine the thought of their interlocutors, it may be remarked that they seem to have acquired a faculty of penetration which enables them to comprehend what has been only half said. The most striking characteristic they present is the wonderful vivacity of their feelings. Thus, nothing is more easy than to make them cry; it is enough only to mention a sad subject to them, when, even if the story which is told them interests them only a little, they will sigh, shed plenty of tears, and sob. In many cases a nervous excitement will be provoked by such narrations, which must be calmed as quickly as possible by causing the subjects to imagine agreeable pictures. This sensitiveness to the troubles of another, these exaggerated compassions, may perhaps be compared to what persons in the first stages of intoxication feel. Sometimes, also, feelings of joy and admiration are pushed to an excess; poetry and music especially will produce a real ecstasy; and it is impossible to forget the spectacle after having once witnessed the power of mimicry which the subjects display. The manifestations of admiration are frequently crossed by childish angers, inexplicable antipathies, and sympathies still more strange than the others. Sometimes the subjects jest, and not without wit; they laugh at the pleasantries they say or commit;

and their laughter, like their weeping, often ends in a remarkable excess of excitement.

One of the most interesting phenomena of somnambulism was described thirty years ago by the Englishman Braid. If we put the limbs of a magnetized person into a particular position or the body into a particular attitude, the feelings which correspond with the position or attitude will be called up by it. Thus, if we thrust out the fists of a subject, his features will immediately take on the expression of rage or menace. If we join his hands in the attitude of prayer, he will fall upon his knees, and his features will give the appearance of one who is engaged in supplication. His face thus assumes the true expression of the passions; and no painter, no sculptor, has succeeded in representing terror, disgust, contempt, wrath, amorous tenderness, religious ecstasy, with as much likeness to the life as do somnambulists, even the least intelligent ones, when we excite those feelings in them. This is because the mind, concentrated upon itself, is not disturbed by any of the external causes of excitement which continually and generally without our knowledge impose a restraint upon our internal feelings. The anger of a somnambulist is a typical anger, ideal, and his countenance will wear the expression of it in a high degree according as the feeling that animates him is strong and unmixed.

The magnetizers make wonderful pretensions. They declare that all these facts are of the earth earthy, and, assuming to rise away above their plane, they have imagined that the intelligence of the somnambulists is capable of pulling aside the curtains from the future, of penetrating the mystery of things that are and will be. They have talked of clairvoyance as a power of seeing without the aid of the eyes, as for example of reading a shut book, of hearing without the aid of the ears, of being present at a conversation which is taking place at the same moment at the other end of the world. Justice must be done to these fables; there is nothing supernatural in somnambulism, any more than in the demoniac attack, and no well-demonstrated fact has ever permitted us to conclude that such a thing as double sight or clairvoyance exists. The somnambulists who are exhibited in the theatres and at fairs, as, for example, the celebrated Lucille who was shown several years ago, are really put to sleep, but the condition of genuine somnambulism into which they have fallen does not exclude them from the power of simulating clairvoyance. They are aware of what they are doing, and they know very well that it is their business to divine the future. They are anæsthetic, and we may pinch them, prick them, burn them, without exciting a painful sensation. The phenomena of catalepsy may also be very easily produced upon them. Their intelligence, over-excited by their nervous affections, enables them to find ingenious answers. In a word, the clairvoyants of the theatres and fairs are really asleep, but they are not diviners, only sick persons, and their true place would be in a hospital for the insane.

The moment of awakening presents curious features; most frequently, somnambulists on waking are in a deep stupefaction; they look at the persons around them without being able to believe the truth of what they are told; they have preserved no recollection of what has passed while they were in sleep; and, since, in a psychological point of view, time is measured only by the remembrance of ideas, they have wholly lost the notion of time. The moment when they were put to sleep is confounded with the moment of waking. It also happens that what took place during sleep returns to their memory when they are newly put to sleep; and this probably furnishes an explanation of the doubling of the personality of which some of the magnetizers speak. It is what we may call the collection of our memories that constitutes the I; and, when we find that certain memories are reserved for a special physical condition, we almost have a right to say that the personality is doubled, because it recalls a whole series of acts in sleep of which it is absolutely ignorant in the waking state.

The hysterical patients of the Salpêtrière can be put to sleep with the greatest ease. Anything that will powerfully excite the senses is sufficient to induce the somnambulic paroxysm—as, for instance, the flash of the electric light, or the metallic, harsh noise produced by suddenly striking the tomtom or the Chinese gong. Sleep comes right on, with such rapidity that the subjects do not even preserve the memory of the shock which has for a time destroyed the consciousness of their existence. If the gong is sounded while the patients are together in one of the courts of the hospital, the greater part of them will stop short with their eyes open and their limbs fixed in an attitude indicating stupefaction mingled with fright. This condition of sleep provoked by a violent shock to the nerves is not at all identical with the somnambulism which is induced by passes. The sleep is deeper, more animal, and, we might say, more pathological; the functions of the nervous system and the muscular system are more gravely disturbed. Insensibility is complete, and the patient, if some one does not wake her up, will remain for hours as if she were annihilated in a sleep without a dream. If the eyes are open, there is catalepsy—that is, the muscles will retain indefinitely the position that has been given them. If, for example, the arm has been lifted into the air and put into an unnatural position, it will continue raised in the attitude that has been imposed upon it. If, on the contrary, the eyes are closed, other phenomena will be brought out. The nerves will have become extremely excitable, so that any muscle may be made to contract by merely placing the finger across the nerve which produces that action. The muscles themselves are also extremely excitable, so that we may make them contract and even draw up by simply touching them. If we insist, we can cause them to draw up closely, and make the fingers double up upon the hand, and the forearm upon the arm. If we waken the patient with-

out having taken the pains to relax the muscular contraction, it will persist for a long time, and it will be almost impossible to put an end to it until a new paroxysm of somnambulism has been brought on.

The symptoms of this curious malady do not appear only among women and persons afflicted with hysteria; they are also observed, though more rarely, among young persons and with aged men. Not only do they arise when they are provoked; they frequently appear spontaneously, without any effort to induce them. Natural somnambulism, which in former times greatly excited the curiosity of medical men, is now a well-described affection. New examples of it are of daily occurrence. Persons subject to it will get up in the middle of the night, dress themselves, start to go out and attend to their business. Their eyes are sometimes shut, sometimes wide open, but they have no real sight. Their vision is all interior, but serves them so good a purpose that they are able to find their way through the furniture scattered around the room without a light. Memory is the unerring guide of their movements. They can read mentally the book which they open, and perform similar actions to those they would be engaged in if they were awake—as, for example, those of swimming, running, writing, and handling arms. If they are suddenly wakened, they will be stupefied at finding themselves up and dressed when they had supposed that were reposing quietly in their beds. Instead of seeking for something marvelous in these phenomena, would it not be better to satisfy ourselves that they resemble those that we may observe in ordinary sleep? The mother, bending over the pillow of her sick child, is able by means of her caresses and soft words to calm the spirit which is distressed by the terrific visions of the nightmare, and make the child sleep more sweetly without waking it. Sometimes, when we are half-awake, half-asleep, as in the evening, for instance, when sleep weighs upon us, or in the morning, when it has not quite left us, we act and speak without being quite aware of what we are doing or saying. This is a light degree of somnambulism; and, if we will study ourselves with a little care, we will recognize that, at the beginning or at the end of sleep, the complete, exact consciousness of our actions and our thoughts escapes us. There is, then, a series of insensible transitions between the common general sleep of the world and the singular sleep, more wonderful in appearance than in reality, of the somnambulists and hysterical persons.

Notwithstanding a whole class of positive facts exist, proved and easy to verify, there are still some medical men who do not admit the reality of them, and are ready to smile at the mention of somnambulism as if a colossal deception were spoken of. In their view, all the cases of this condition of sleep are nothing but comedies skillfully played before too simple spectators by nervous women who have been made fanatical by delirium. They believe this because they have been satisfied with witnessing the acrobatic scenes which the magnetizers

and the professional somnambulists offer as a spectacle to the credulity of the public. If they had observed for themselves, if they had handled with their own hands and seen with their own eyes the phenomena of which they deny the existence, I do not doubt that they would have had an entirely different opinion. Is it possible to suppose that all the somnambulists that have appeared during the last hundred years would have feigned the same symptoms just to conform themselves to the fancies of the little peasant Victor, the first case of the Marquis de Puységur? How, by what strange divination, can they all exhibit the same signs of the same nervous affection? Would it not be a really marvelous fact if a deception carried on for a hundred years through all Europe should everywhere and always present the same features, and if all the physicians, all the men of science who had devoted themselves to the study of it, should have become victims to the same unexplainable imposture?

Somnambulism must, then, be regarded as a veritable disease, the symptoms of which are as well described as those of hysteria and epilepsy. The only remarkable and obscure side of the study of it is that the nervous affection can be induced by exterior manœuvres, the method of the action of which escapes us. Our ignorance of the cause of the phenomenon furnishes us no reason for denying its existence. Hereafter, possibly in the course of a few years, we may arrive at an exact acquaintance, not with the symptoms, which are quite well known now, but with the physiological causes of somnambulism. We have reason to hope that the empirical processes which are at present employed will be replaced by scientific methods, the trustworthiness of which no one will be able to put in doubt, and the efficacy of which will endure every test.

We have seen, in the course of these investigations, that there are diseases which, without producing insanity properly so called, deeply disturb the functions of the understanding. The disturbances they occasion are certainly wonderful, and calculated to excite surprise; but we are justified in affirming that they are subject to natural laws, and not to the fancy of the seven million four hundred and five thousand nine hundred and twenty-six devils of hell. This was not the opinion of the judges of the seventeenth century; and it is not one of the least of the benefits that science has conferred upon us, that it has affirmed and proved the innocence of the miserable sufferers from these diseases who were formerly consigned to the stake.

NOTES ON A FEW OF OUR BIRDS.

By HARRY MERRILL.

MUCH has been said and written in regard to the fact that birds temporarily change their habits and customs, and adapt themselves to surrounding circumstances so as to meet their immediate wants and necessities; and these changes are by no means rare, but occur whenever anything is interposed which may conflict with their usual methods of practice. In some cases these habits have been perpetuated, and have become the established custom of a number of species. Our martins and chimney-swallows have almost entirely deserted their original quarters in hollow trees for those that have been furnished by the advent of man. Some sea-birds, that in Labrador build nests and raise their young in the usual way, in the south abandon their eggs to the sand and sun, which perform the duties of a parent in the most acceptable manner. It is noticed that birds which usually build on the ground, particularly sparrows, frequently build in bushes or even in low trees. This is very often the case in pastures where the nest and eggs would be liable to be destroyed by being trodden on by cattle or sheep; in such a situation I have found a nest of the song-sparrow at a height of six feet.

During the past few years I have met with many instances where birds have so changed their habits; and the purple grackle or crow-blackbird has furnished several examples of this kind. These birds are quite common, and rule with undisputed sway over the groves in which they dwell. One of these nesting-places is situated on the banks of the Kenduskeag River in Maine, in a most beautiful spot, where steep ledges rise abruptly from the water's edge, and are covered with a rich growth of pine and cedar, together with wild flowers and climbing plants. Here these birds for many years have built their nests, a single tree often containing several of them; they are very bulky affairs, composed of mud, weeds, and similar materials, and lined with hay.

Peace and prosperity dwelt in this little colony until a few years ago, when the destroyer, man—or rather the father of the man, the boy—commenced to collect birds' eggs; then this spot offered a rare field for his depredations, and one that was not overlooked, so that in a short time many were robbed of home and its treasures, and driven from their ancestral grove. Thereupon, large numbers of the birds proceeded to a lumber-yard situated on the river a short distance below, and, seeking there that peace which the grove failed to give, commenced building their nests in the huge piles of boards which lined the water's edge, and in this peculiar situation they began anew the battle of life and reared their young.

In 1874 I found a pair of these birds occupying a woodpecker's deserted hole, and every new year finds them in their old abode, in spite of the fact that they were once robbed of all their eggs, showing very plainly how attached they become to their old haunts, and that even to a blackbird "there is no place like home." Audubon says that in the South the crow-blackbird frequently makes use of holes in trees, where a few dry weeds and feathers are collected on which the female deposits her eggs; Burroughs, also, notices that this bird, "seized with a fit of indolence, drops its eggs in the cavity of a decayed branch." In New England, however, this is not often the case, and in the instance mentioned indolence was clearly not the cause of their selecting this residence, for the nest was constructed exactly similar to those built in trees. I also found a nest of this species in a low marsh which was occupied by red-winged blackbirds as a nesting-place. This nest was built in low bushes about eighteen inches above the water, and was in structure like the redwing's nests among which it was placed, there being *no mud* used in the construction. This case, so far as I can learn, stands alone as a peculiar instance of adaptation to surroundings as exhibited by these birds.

Every one in New England probably knows the night-hawk, though persons generally are but little interested in it, and very few indeed become well acquainted with its habits. This may be partly due to the fact that it has no song to recommend it, but is principally owing to its habit of remaining perched along some limb during the daytime, when, on account of the similarity of its coat to the branch on which it rests, it remains unnoticed by the casual observer. At the approach of evening, however, he ascends into the air, and there darting about in every direction he procures his food, which consists of various kinds of insects; now he is by no means silent, but makes the night resound with his shrill cries, varying the entertainment occasionally by diving from a great height with partially closed wings, and making a noise which, as Nuttall says, resembles the sound produced by blowing into the bung-hole of an empty hogshead. Early in June you may perhaps witness their courtship. The male is all attention, strutting around with spread tail and ruffled feathers, for all the world like a miniature turkey-cock; stopping now within a short distance of his charmer, he ducks his head and wags his body from side to side, uttering all the while a growling sound which seems to come from the very depths of his distended throat. During this time the female is apparently regardless of this mass of fuss and feathers, and sits perfectly still—a sweet picture of modesty; this is continued for some time, when off my lady goes sailing through the air, leaving her suitor to follow at his leisure. Audubon says, "The male may be said to court his mate *entirely on the wing*, strutting as it were through the air." In this statement, however, he is hardly correct, as for the last three years a pair of these birds have used a roof a few feet from my window as a

trysting-place, and there evening after evening the little domestic drama just described was enacted, thus offering me a superior opportunity to witness their love-making.

The night-hawk builds no nest, but deposits her two speckled eggs on the ground, usually selecting some ledge for this purpose. Birds of this species are very numerous in New England, and in walking a few rods I have often seen numbers of them perched on the trees which border our streets. Still, for a long time I had been unable to find their breeding-grounds, for there seemed to be no suitable places near their favorite resorts; at last, however, I found that they made use of the house-tops for this purpose, and several pair with young or eggs were discovered so situated. I have never seen the fact mentioned, but it is undoubtedly true that these birds return to their old haunts year after year, and deposit their eggs on the same spot for successive seasons. Some years ago I found two young birds just out of the shell; and the next year, being in that vicinity, I had the curiosity to visit the place, and there on the very same spot were two eggs; again the following season it was occupied by the birds. They sometimes raise two broods in a season, as was proved to me by finding two young birds about to fly, and shortly after two more eggs were deposited on the same spot. This is, I believe, contrary to their usual practice, however. A very strange peculiarity which these birds exhibit is that of removing their eggs upon being disturbed during incubation. I visited a pair that had deposited their eggs on the house-top, and the next day was surprised to find them gone, for the situation rendered them unapproachable by other than myself; but a little search revealed the fact that the eggs had been moved to another part of the roof, about a rod from their former resting-place. This removal is perhaps made by taking the egg in their very large mouths, in the manner described by Audubon. In speaking of chuck-will's widow, an allied species found in the South, he says: "When chuck-will's-widow, either male or female (for each sits alternately), has discovered that the eggs have been touched, it ruffles its feathers and appears extremely dejected for a minute or two, after which it emits a low, murmuring cry, scarcely audible at a distance of more than eighteen or twenty yards. At this time the other parent reaches the spot, flying so low over the ground that I thought its little feet must have touched it as it skimmed along, and, after a few low notes and some gesticulations, all indicative of great distress, takes an egg in its large mouth, the other bird doing the same, when they fly off together, skimming closely over the ground, until they disappeared among the branches and trees."

On any of our streams or lakes, whether in the unbroken forest or where civilization reigns, we may find the kingfisher perched on some stake or rock, surveying the water beneath him with eager eye in search of his finny prey, or skimming over the surface and uttering his harsh cry, which is so similar to the sound of the watchman's rattle

that we can easily imagine some guilty sojourner in our native wilds, who hears it for the first time, starting from his slumbers, thinking that the Philistines were upon him.

In Williamson's "History of Maine" is given a list of our native birds, or what purport to be so, and there a very strange mistake is made in his description of the kingfisher. He says, "It is heavy as a plover, has a long bill, its head is crested with *red*, its back is of a blue color." He also says that this bird is plentiful, but it is very evident from his description that he never examined one, since the bird's entire upper parts, including the head, are ashy blue. These birds excavate in sand-banks a hole about six feet deep and three and a half inches in diameter; this hole is enlarged at the end, where, as Audubon, Nuttall, Samuels, and other authors agree in saying, a nest is built, composed of grasses, leaves, feathers, and perhaps a few sticks, on which the eggs are deposited. This, however, is not the case in central Maine, for I have examined a great many of their burrows, with a view to ascertaining the facts regarding the construction of their nests, and in *not a single instance* has there been the slightest attempt at the formation of a nest, but the eggs were laid on the bare sand, over which in some cases fish-scales were scattered. I have spoken with many persons in different parts of this State in regard to these facts, and their observations have agreed with my own. Mr. H. D. Minot, in his "Land and Game Birds of New England," says: "From the abundant evidence recently offered on the subject of the nest, and from my own limited experience, it may be gathered that it" (i. e., the burrow) "varies in length; . . . that it may be either straight or have a bend, and that it is rarely lined at the end, except with *fish-bones*, as is sometimes the case."

When all Nature is covered with her snowy mantle, and our feathered friends have deserted us for more congenial climes, we may still see the red-bellied nuthatch hopping about on our trees, peering into crannies in search of food, and uttering their short and ceaseless note; but, as the weather grows milder, they gradually disappear, going away to the north, where they breed. The author of "Land and Game Birds of New England" notes that a nest was found in Roxbury, in 1866, but the instances recorded of its nest and eggs being found in New England are not common, and for this reason I trust the description of a nest and eggs which I was so fortunate as to find may be of interest. On the 23d day of May, 1877, while passing through the woods on a collecting tour, I chanced to place my hand on an old and very much decayed hemlock-stub, but no sooner had I touched it than a red-bellied nuthatch popped out of a hole about six feet from the ground, and, feeling sure of a prize, I proceeded to inspect her snug quarters. The nest was placed in a cavity in the stub, which extended downward about six inches below the entrance: at the bottom of this hole was the nest proper, which was composed entirely of soft bark;

it was about three and a half inches across and slightly hollowed, perhaps three quarters of an inch. This nest contained six eggs, speckled with reddish-brown.

Around the hole on the outside of the stub a circle of fresh pitch had been smeared by the birds, perhaps for the purpose of keeping out the ants with which decaying stumps are apt to swarm. I have never before heard or read of this habit; none of our ornithologists, so far as I can learn, make any mention of the fact; but since the above instance came to my notice I have learned of another case of the kind, where the stub was a white birch, showing that my example was not altogether exceptional, and the fact that it is unnoticed by our ornithologists may be owing only to a scarcity of observers.

The geographical range of different species of birds is not so definitely marked as might be supposed, for, although there are certain well-defined boundaries which separate the birds of different parts of the world, and of different parts of the same country, yet these limits are being constantly broken over by accidental visitors from other countries, by the birds increasing their range, or by stragglers from other ornithological districts of the same country. A South American hummingbird was obtained at Cambridge, Massachusetts, a few years ago. The Egyptian neophron has been shot in England, and the European corncrake is occasionally found on the Atlantic coast of the United States.

The cliff or eave-swallow, perhaps, furnishes the best example of increased range to be found among our birds. When first discovered it was apparently confined to limited areas in the West and Southwest, but at present it spreads over nearly the whole country and is yearly increasing its limits.

In order to be more fully understood in speaking of ornithological districts, it may be well to cite as examples the two regions of New England sometimes called the Alleghanian and Canadian. These districts are divided by a line drawn from the coast of Maine, near Mount Desert, and running southwesterly on the ridge of high land which extends across the southern portion of the State into the highland region of New Hampshire, thence running northwesterly across Vermont. This division is so marked that some birds that are common in the southern district are almost unknown in the northern, where they may occasionally appear, however, as stragglers. Much more striking examples are sometimes seen, as in the case of a cardinal grosbeak that was shot at Orrington, in Maine, a few years since—this bird's habitat being the southern portions of the United States.

I recently had the pleasure of following up and reporting a most interesting case of the finding of birds beyond their supposed limits. In this instance the bird was the loggerhead shrike (*Colluris ludovicianus*), which is a resident of the Southern States, and not supposed to breed in New England. As the case is one of considerable interest,

I shall state the facts in full. On May 5, 1877, a nest, four eggs, and parent bird, were obtained near Bangor, Maine, which the finder believed to be the great northern shrike (*C. corealis*), and it was described as such in "The Oölogist." Later in the same year another nest was found, and the parent bird shot. The following year four more nests were obtained, and some eight birds procured, some being immature specimens. During this latter season (1878), I obtained some of the specimens mentioned, and was surprised to find that they were not great northern but loggerhead shrikes. Soon after this, at the request of Dr. T. M. Brewer, of Boston, I made a thorough inquiry into the facts concerning the breeding of shrikes near Bangor, and then examined all the specimens of both birds and eggs that had been procured. The result showed that there was not a single authentic instance of the great northern shrike's breeding in this vicinity—every reported instance proving that the bird in question was the loggerhead species.

Until brought to my notice, these birds had never been known to breed in New England, and I had the gratification of being the first to so report them. Minot, in his "Land and Game Birds of New England," says that "they are but rarely found as far north as Massachusetts." Since their discovery here, however, Dr. Brewer has been making extended inquiries into the breeding of the shrikes in New England, and it now appears that in several other cases, where great northern shrikes were reported as breeding, the birds have proved to be loggerheads. This was true of the specimens found at Rutland, Vermont, as stated by Dr. Brewer in the "Ornithological Bulletin" for April, 1879. These birds now appear to be regular visitants in this vicinity, and are among our earliest arrivals. About the first of May of this year (1879), I found a nest containing one egg, and on the 28th day of the same month I found another nest with six young.

All of the nests found here, so far as can be learned, were situated in rather open fields, and none were in the deep woods. The birds were not easily alarmed, and apparently cared but little for the presence of man. Sometimes they would perch on an adjacent limb and watch me, as I examined their nests, without showing a sign of fear. It is certainly quite remarkable that a bird with such marked characteristics should dwell with us long, if indeed it has done so, and yet escape notice; and the number of instances of its breeding here which have been reported since its presence was first noted is also remarkable if it is a straggler.

The author of "Land and Game Birds of New England" claims the honor of being the first to discover the nest of the golden-crowned kinglet (*Regulus satrapa*), which discovery he made in 1875 in a forest in the White Mountains. This nest contained six young birds, but no eggs.

Wilson and other ornithologists, believing that the European "gold-

crest" and our *R. satrapa* were the same, took a description of the nest and eggs of that bird and applied it to our "golden crown," but the birds are not identical.

If Mr. Minot is correct, as he undoubtedly is, it is probable that I have the pleasure of possessing the first and possibly the only nest and *eggs* of this bird ever found. In 1876, the year following Mr. Minot's discovery, I obtained a nest which contained ten eggs. It was found near Bangor, Maine, and was placed about six feet from the ground in a mass of the thick growth so common in many of our fir-trees. The nest was composed of a large ball of soft moss, forming a mass about four and a half inches in diameter. The opening was at the top, and was about one and three fourths inch across and two inches deep; this opening was lined with hair and feathers, principally the latter.

To the eye the eggs appear of a creamy-white color, covered with such very obscure spots that they merely give a dingy or dirty tint to the egg; but Dr. Brewer, who examined them by the aid of a powerful magnifier, states in the "Ornithological Bulletin" for April, 1879, in which he gives an account of these eggs, that "the ground-color is white, with shell-marks of purplish slate, and a few obscure superficial markings of a deep buff, giving to the ground the effect of cream-color." These eggs are extremely minute, the largest being only $\frac{52}{100}$ of an inch long and $\frac{41}{100}$ of an inch in breadth, while the smallest is $\frac{47}{100}$ of an inch long and $\frac{39}{100}$ of an inch in breadth, or about the length of the egg of the ruby-throated humming-bird. These ten tiny eggs in their mossy casket can hardly be excelled for simple beauty.

There are many persons who do not feel particularly interested in natural history in general, but who are nevertheless charmed by our beautiful birds and their sweet songs, and, being touched through the medium of their senses, they come by degrees to learn more and more of their habits, till the charm so grows upon them that without our feathered friends life would lose one of its greatest pleasures. Yet, perhaps, no living creatures are so much abused, being a convenient target for every boy who is large enough to carry a gun or throw a stone. In some localities there is a constant robbery of their nests, carried on to an alarming extent, which the law is practically powerless to prevent. Take a single example of failure to enforce the law in another direction: I am informed that over seven thousand ducks were netted contrary to law in Franklin, Maine, last year, by pot-hunters, and all over our State this business is carried on with impunity, and probably will continue to be till public sentiment is aroused to a proper realization of the fact that our waters are gradually being stripped of their water-fowl, and when it is, perhaps, too late, the wrong which has been permitted may be appreciated but too well.

THE NEW CHEMISTRY, A DEVELOPMENT OF THE OLD.

By M. M. PATTISON MUIR, F. R. S. E.

IN a former paper* I endeavored shortly to summarize the more important differences between that system of chemistry which was founded on a so-called equivalent notation and the modern, or atomic phase of the science. The general conclusion to which that summary led was, that the old chemistry was empiric, while the new is scientific; but, as was there remarked, empiricism precedes science: science is the natural development of empirical statements, and is not to be regarded as entirely a new departure.

Believing, as I do, that the old and new chemistry are essentially opposed in their methods, I nevertheless am certain that the germs, at least, of many of our modern chemical theories are to be found in the statements, and even in the hypotheses, of the workers of half a century since: and in the present paper I propose to trace, in a little detail, what I believe to be a correct outline of the development of two of the more important theories of modern chemistry. †

The chemical views most in vogue before the strictly modern epoch were founded more on considerations of the composition of compounds than on the actions of these compounds. Dumas introduced wider views by recalling the attention of chemists to the fact that, in order to frame even a tolerably complete system of classification, an answer must be given to the question, "What does this substance do?" no less than to the other question, "Of what is this substance composed?"

But, if we go back to the time before Lavoisier and his associates, we find that the system then predominant in chemistry was founded almost entirely on the reactions, and but to a very small extent on the composition, of chemical substances. Chemists then busied themselves continually with studying processes of chemical change; only they contented themselves with qualitative knowledge, and hence their hypotheses were for the most part extremely vague and their facts disconnected. John Joachim Beccher, born about 1630, seems to have been the first to weave together the scattered chemical facts and guesses into a consistent general theory, which was subsequently augmented and defined by Stahl (1660–1734).

Looking at the wonderful changes produced in substances by the action of chemical force, the question arose, What happens when a body undergoes chemical change?—and, as burning or combustion was

* "Popular Science Review," January, 1878.

† In the paper referred to, I briefly sketched the history of the development of the older doctrine of "Equivalents" into the modern hypothesis of "Valency."

perhaps the commonest of all chemical changes, the question became narrowed, and chemists eagerly sought for an answer to the query, "What happens when a chemical substance burns?"

In those days natural phenomena were referred to the presence of "principles" or "essences" in the matter exhibiting the phenomena. A new principle was added to the list; and the question was supposed to be solved by saying that combustible substances are characterized by richness in *phlogiston* (Gr. *phlogizō* = burn, or inflame), and that when they burn they lose this principle, so that the burned substance, or calx, consists of the original substance *minus* phlogiston.

The phlogisteans seem to have regarded their hypothetical principle as a modified form of fire, as fire confined in a material substance; but, as they gave no definition of fire, beyond saying it was one of the four elements, it was scarcely to be expected that they should define phlogiston. By restoring phlogiston to the burned substance, said the theory, the original matter is regenerated. Some substances, e. g., charcoal, are especially rich in phlogiston, and metallic calces may be converted into metals, i. e., may be unburned, by heating them with charcoal. Thus the phlogisteans regarded the phenomena which they studied in a purely qualitative manner: they asked only, What does this or that substance do under given conditions? not being aware that a full answer to this question can only be given when the other question—*How much* of some given effect is produced by a given quantity of this body under stated conditions?—had been answered.

The introduction and use of the balance carried the day in favor of those who opposed phlogistic views. If a substance loses something when it burns, it *must* weigh less than before burning—as a fact it weighs more—therefore it has not lost but gained something.

"Nay," replied the phlogistean, "it has lost something, but the weight of this something can only be expressed by a negative quantity."

"But a something with such properties is an absurdity," replied the opponent; "therefore it has no existence, and therefore your theory is utterly false."

The anti-phlogistean triumphed, and the principle of levity was banished from chemical science. But the principle returned in a modified form. Lavoisier, who opposed the Beccherian theory of phlogiston with signal success, himself propounded a theory of the constitution of solids, liquids, and gases, in which the "subtle principle" "*caloric*" played an important part. Lavoisier regarded oxygen as what he termed "concrete oxygen" *plus* a something—caloric; indeed, he appears to have looked on all substances in the concrete state as solids, and to have supposed that the addition of a certain quantity of caloric to these caused them to become liquids, while the addition of a further quantity of caloric produced gases.

Thus chemists seemed obliged to imagine a something in addition to the gross or ponderable matter of which bodies are composed, in order to account for the properties of these bodies. As Science has advanced she has been able to define what this something is; at least, she has defined it more clearly than the older workers could do.

I have said, as Science has advanced she has defined the unknown something; but it should be remembered that that wonderful book, which contains—according to the greatest authorities—the germs of all our modern advances, was written sixty years before Lavoisier's time. Sixty years before the apparent overthrow of the theory of phlogiston, Newton had laid the foundations of the science which was to reveal the true lineaments of that Unknown whom the phlogisteans ignorantly worshiped.

We have learned to extend the meaning of the word *thing*—we speak of "the power of doing work" as a measurable and definite thing—although not as matter: and we know that when a body burns it loses a certain amount of this power of doing work, or, as it is more shortly put, of energy. As usual, it is a question of words. The older workers could not define phlogiston; we are able to define energy, and therefore we can see clearly where they saw but darkly. Chemistry now acknowledges that the properties of a compound are not only determined by the composition of the matter of that compound, but by the amount of energy associated with that collocation of matter. She has been able to point out many instances of compounds composed of the same matter, but possessed of different amounts of energy, and, at the same time, of very different properties. And, moreover, chemistry aided by physics has concluded that the properties of a body "are dependent on the variations of the energy of the body, and not on its total value," and therefore that "it is unnecessary, even if it were possible, to form any estimate of the energy of the body in its standard state." (I quote from that remarkable little book of the late Professor Clerk Maxwell, "Matter and Motion.")

Whenever Science made the advance from the vague conception of "principles" and "imponderable matter" to the definite conception of "mass," "motion," and "energy," she was able to recognize the truth which lurked under the cumbersome and inexact nomenclature of the phlogistean chemists.

I have said that, as usual, the dispute between the phlogisteans and their opponents was proved to be a question of meaning of words: as usual, also, subsequent research showed that, while both were wrong, both also were right.

Composition is important, but composition is not all. The burned body has properties differing from those of the unburned body, because it has lost a certain amount of "the power of doing work"; but it has a less power of doing work because it is possessed of a structure different from that which it possessed before. Composition and properties,

energy and structure, are closely connected: to determine the exact relations existing between these, under stated conditions, is still the fundamental problem of chemical science.

We can define energy: the phlogisteans could not define phlogiston. But in the ethereal philosophy of the future will it not be said of the present workers in science that they could not define ether, but even spoke of it at times as "not gross nor ponderable matter"? The theory of phlogiston was continued and developed in the theory of caloric: the theory of caloric is vastly extended, simplified, and rendered definite in the theory of energy, and the theory of energy seems destined to be largely extended by the ethereal theory now in its infancy.

Mankind has until lately been content with space of three dimensions, but the bolder and more dashing spirits among the mathematicians have dared to look forward to a better world than this where they may revel in space of four dimensions. What a strange world must that be! what a fearful place for a mathematical examination, when we remember that the inhabitants thereof—if there be inhabitants—may turn spherical hollow balls inside out without tearing or breaking them!

While we look forward to the future of science with hope, I think we ought not to look back on the former workers without respect.

But I must pass on to consider the second of the great theories which have paved the way for the doctrines of modern chemistry. The germ of the modern ideas of substitution, valency, atom-linking, etc., is, I believe, to be found in the pure dualism of Berzelius; and, moreover, the influence of the dualistic ideas of that great chemist seems to me easily traceable in the essentially unitary system of modern chemistry. The chemistry of Lavoisier centered around the wonderful substance whose properties he so carefully studied. The teaching of the great founder of modern chemistry was saturated with ideas suggested by the study of oxygen. The compounds of oxygen were divided by Lavoisier into two groups, bases and acids: when these reacted chemically, a salt—that is, a body made up of base and acid—was produced. Berzelius developed these ideas until he had constructed a complete and beautiful theory, viewed in the light of which all compounds were of analogous structure. Every chemical substance was made up, according to the Swedish chemist, of two parts; these parts might themselves be composed of simpler parts, or they might be truly elementary. The two parts of a compound were respectively endowed with positive and negative electricity. When two bodies combined, the positive electricity in one neutralized the negative electricity in the other; hence the phenomena of light and heat noticed in chemical combination. An element might contain an absolutely greater quantity of positive electricity than another and nevertheless belong to the electro-negative series of elements: thus sulphur and oxygen readily combine to form a substance which, when dissolved in water, yields an

acid. But oxygen and sulphur are both electro-negative elements. Berzelius supposed that sulphur contained a large quantity of both electricities, the negative predominating. When this element combined with oxygen, the positive electricity of the sulphur was supposed to be neutralized by the negative electricity of the oxygen, so that the negative electricity of the sulphur was concentrated or rendered more apparent. The affinity between oxygen and silver is less than that between sulphur and oxygen, because, said Berzelius, silver contains mainly positive electricity, but a smaller quantity than is found in sulphur. The product of the union of oxygen and sulphur, i. e., of oxygen with an electro-negative body, belongs to the class of acid oxides; the product of the union of oxygen and silver, i. e., of oxygen with an electro-positive element, belongs to the class of basic oxides.

If this view of the composition of oxides were granted—and a most ingenious and plausible theory it was—why should we not proceed a step further and say that an acid acts so readily upon a base, because, in the first, negative electricity predominates, while the prevailing electricity in the latter compound is positive?

And, in further support of this view, could it not be experimentally demonstrated that when a salt, such as sulphate of sodium, is decomposed by the electric current, the soda goes to the negative pole, while the sulphuric acid appears at the positive pole? The experiment of decomposing a solution of sulphate of sodium was frequently performed, and the fact that, if the solution were colored with litmus, that portion around the negative pole retained its blue color, while that around the positive pole became red, was regarded as conclusive evidence of the dualistic structure of the salt operated upon.

But, about the year 1834, Dumas told the chemical world that chlorine was capable of "laying hold of the hydrogen of certain bodies and replacing it atom for atom." If this be so, said Berzelius, the compound formed must differ essentially from that from which it is derived. Chlorine is an electro-negative element, and, if it enter into a compound in place of the electro-positive hydrogen, the original compound and the new compound can present no points of analogy. The theory seemed correct, but unfortunately the chlorinated body did present very marked analogies with that from which it had been produced. Berzelius attempted many explanations, invented many new compound groups of atoms, which should be supposed to enter into the composition of the new bodies discovered by Dumas; but his electro-chemical theory was doomed. It was gradually abandoned by most chemists, and the substitutionists carried the day.

Berzelius had largely availed himself of certain facts, which showed that, in series of reactions, it was sometimes possible for a group of dissimilar atoms to remain intact, to move about, so to speak, from one compound to another without falling to pieces. Reasoning on

these facts, he constructed formulæ for all compounds, which formulæ were made up of two parts, or radicles. The idea of compound radicles was thus closely associated with the dualistic theories of the Berzelian school. The new school, led by Dumas, finding dualism insufficient to explain many weighty facts, naturally waged war against the fundamental conception of compound radicles, but they were soon obliged to accept the essential truth of the theory which they at first opposed. Liebig and Wöhler's research on oil of bitter almonds led to the discovery of a number of compounds, exhibiting many general analogies, which could best be explained by supposing the existence in each of a compound radicle, or group of atoms. When it became necessary once more to adopt the idea of compound radicles, the theory of substitution was found to be strengthened, not weakened, thereby. Many reactions were made clear by supposing that an element might be substituted by a group of elementary atoms, by a compound radicle. But in adopting the idea of compound radicles the substitutionist yet maintained that the chemical compound was a distinct whole, made up of parts he admitted, but, nevertheless, having these parts so modified and merged in one another that the resultant acted as an homogeneous compound. Thus, when the new school likened the ethers to the metallic oxides, they did not mean to assert that the molecule of ether was composed of two parts, ethyl and oxygen, held together by electric bonds, and ready to part company without difficulty; nor, in asserting that ether was one substance, and not a dualistic system, did they deny the existence of a structure within the molecule of ether. They admitted the existence of a closer relationship between the atoms of carbon and hydrogen constituting the group ethyl than between these atoms and those of oxygen, and they generalized the reactions and analogies of ether, by saying that it might be regarded as sodium oxide in which both sodium-atoms had been substituted by two compound atoms of ethyl. Berzelius had himself likened the ethers to oxide of potassium, and by doing this the great apostle of dualism had paved the way for the advance of the unitary theory.

That portion of the dualistic doctrine which was embodied in the theory of compound radicles was adopted by the unitary schools, but adopted in a modified form; the effects of this modification were not long in making themselves felt.

Berzelius, in his later works, had been ready to give a dualistic formula to any compound without stopping to inquire into the facts known about that compound; he had tended to forsake the only true scientific method, and to substitute the vagaries of his fancy for the facts of nature. The new school averred that "compound radicle" was an expression generalizing a class of facts; that the reactions of bodies were most simply explained by supposing that when acted on by chemical force the little parts of these bodies behaved as having a definite structure; and that therefore the formula of a given body

might be written as containing different compound radicles under different conditions.

The fault of the old chemistry was that more attention was paid to symmetrical formulæ than to reactions; the merit of the new consisted in bringing the student once more back to nature.

And the appeal to nature was answered, and answered abundantly. The new conception of compound radicles was rich in results; from it there was developed—first, the theory of types, and, subsequently, the wider theory of valency, which has led to that of atom-linking, and these in their turn have reacted on the older and more fundamental notions of the science, and have given a new meaning to such terms as "chemical" and "mechanical actions," "compounds" and "mixtures," etc., while, at the same time, they point the way to the chemistry of the future when we shall have gained a definite conception of the inner mechanism of the molecule, and of the laws which regulate the combinations of molecules in groups, and the decompositions of molecules with subsequent formations of new atomic systems.

Let us shortly examine these ideas. If sodium be thrown on to water, caustic soda is produced, a substance made up of hydrogen, oxygen, and the *simple radicle* sodium; by another reaction a substance can be obtained consisting of hydrogen, oxygen, and the *compound radicle* nitryl (NO_2). These two bodies have analogous formulæ, Na OH and (NO_2) OH, they may both be regarded as derived from water, H HO, by the replacement of one half of the hydrogen by a radicle; in one case by Na, in the other by NO_2. Again, the whole of the hydrogen in water may be replaced by sodium, with production of the compound sodium oxide, Na_2O.; but in many of its reactions this compound is the analogue of common ether, which is also a compound of oxygen with a (compound) radicle *ethyl*, and has the formula $(C_2H_5)_2O$. Now, these substances, Na OH, (NO_2) OH, Na_2O, and $(C_2H_5)_2O$, both on account of the methods by which they are produced, and because of their general reactions, may be classed together as derivatives of water, or may be said to belong to the *water-type*. Similarly, other types have been instituted, and large groups of compounds have been brought into the same class as being all referable to one parent type. This step in advance is evidently an outcome of the theory of compound radicles; without that conception a system of classification by types would have been impossible.

But it was found that while such compound radicles as C_2H_5 or NO_2 were capable of replacing but one part by weight of hydrogen in water, other compound radicles, such as CO or C_2H_4, were capable of taking the place of two parts by weight of hydrogen. Comparing together these two sets of radicles, it might be said that $CO = 2\ NO_2$ or $C_2H_4 = 2\ C_2H_5$, so far as the power of combining with hydrogen was concerned. This conception of binding power being extended to the elements, and being deepened and widened by laborious experimental

researches, led to the general theory of valency, which included in itself the essential features of the older doctrine of equivalents.

Having thus gained the conception of a definite binding power as applicable to elementary atoms or groups of atoms, it followed, as an almost necessary deduction, that the smallest parts of chemical compounds which existed as distinct chemical entities, i. e., the molecules, must have a definite structure: that the parts (atoms) of the little systems must be arranged in accordance with the valencies, or binding powers, of these parts.

Hence, given the number of atoms in a molecule, and the valency of each atom, it became possible to calculate the number of different arrangements of these atoms which could be produced; and careful experiment has often succeeded in preparing all the different, theoretically possible, compounds. The difference of properties of such compounds, i. e., of compounds the molecules of which are constituted of the same number of the same atoms, but differently arranged, is attempted to be indicated in the "structural" or "rational" formulæ of modern chemistry.

Berzelius spoke of compounds composed of parts held together by mysterious bonds: the idea survives in these structural formulæ of to-day, only we are now able to define what we mean by the smallest part of a compound having a chemical existence, and we have gained certain generalizations which enable us to trace with some degree of accuracy the relationships which exist between the inner parts of these smallest chemical wholes. We appear to be now fairly embarked in the prosecution of molecular dissection, and our chief guide is the theory of valency, itself a development of the dualistic chemistry.

Each elementary atom, I have said, seems to have the power of directly binding to itself a maximum number of other atoms; but it would further appear as if the groups of atoms thus produced had also a certain binding power, but this more indefinite than the atomic binding power, and very variable under different physical conditions. This atomic binding power appears to have a fixed maximum value, but not always to reach the maximum. What is the exact way in which the binding power or valency of the elementary atoms is influenced by definite changes in physical conditions? This is one of the most important unsolved problems of general chemistry.

Then, again, granting the existence of an inner structure to the molecule, granting that groups of atoms do exist in the molecular building, does the fact, that in a certain reaction certain atoms are withdrawn as a group, prove that these existed in the form of the same group in the original molecule? In other words, do our structural formulæ express the relative collocation of atoms within the molecule while the molecule is unacted on by extraneous force, or do they merely roughly represent the condition of things when the molecule is in a state of strain, because of the stress between its parts and

those of another molecule, or molecules, brought within its sphere of action? Here is another question which can only be answered after much experimental evidence has been accumulated. Now, these questions, I make bold to say, are the direct outcome of the dualism of Berzelius, modified by the unitary chemistry of Dumas and his followers.

If we glance back on the development of the two theories, the course of which I have endeavored to outline, we find that both began with a purely qualitative study of reactions, but that it was only when to this had been added the careful use of weights and measures that any solid advance became possible. Further, we find that the older theory was founded chiefly on a study of reactions, while that which was broached after the time of Lavoisier was founded most largely on a study of composition. With the phlogisteans *function* was of paramount importance; with the dualists *composition* was all. The modern theories, which have been developed from these, have attempted, with varying success, to combine both considerations. And if we examine the latest advances of theoretical chemistry we still find it at work on these two lines of advance. The composition of chemical compounds is studied by the majority of chemists; but the general laws of action of chemical force itself have of late received most important elucidation.

Again, if we look to the "lines of advance along which dynamical science is working its way to undermine, at least, the outworks of chemistry," we can distinguish two, essentially the same, lines as were used by the two classes, whose theories I have dealt with in this paper. "One is conducted by the help of the hypothesis that bodies consist of molecules in motion, and it seeks to determine the structure of the molecules and the nature of their motion from the phenomena of portions of matter of sensible size. The other line of advance, that of thermo-dynamics, makes no hypothesis about the ultimate structure of bodies, but deduces relations among observed phenomena by means of two general principles, the conservation of energy and its tendency toward diffusion." (Clerk Maxwell, "South Kensington Science Conferences," 1876, p. 145.)

I have thus sought to substantiate the claim of the new chemistry to be a development of the old. I believe that, if this claim is granted, the conclusion to be drawn must be, not that the old is better, but that to return to that which is admittedly an early stage of development would be to misread all the teachings even of the old chemistry itself.

In examining the progress of Science we see that she is not afraid to retrace her steps, and that she is able to retain and develop all that is probably true, while rejecting all that is proved to be false; and, when we learn that she does this, can we hesitate to find in her history the "promise and potency" of a mighty future?—*Popular Science Review.*

SKETCH OF FRIEDRICH MOHR.

By FREDERICK HOFFMANN.

ON September 28, 1879, the earthly career of a man closed at Bonn, Germany, whose numerous original researches and contributions to pharmacy, chemistry, chemical analysis, geology, and other branches of the physical and applied sciences, have placed him in the foremost ranks of scientific investigators. KARL FRIEDRICH MOHR was born November 4, 1806, at Coblentz, on the Rhine, where his father was an apothecary. After having completed the full course of the gymnasium of his native city, he entered, in 1823, his father's establishment as an apprentice. In 1828 he went to the University of Heidelberg, where he applied himself to the study of philosophy, the natural sciences, and pharmacy, and where, by the influence and guidance of Leopold Gmelin, his interest was particularly drawn to chemistry; he subsequently studied at the Universities of Berlin and Bonn, and in 1831 graduated as doctor of philosophy. After having passed the state-examination as apothecary, in 1832, he returned to Coblentz, and became the assistant, and, in 1840, the successor of his father, in business.

Mohr's first literary production was an essay on the nature of caloric and the conservation of force, published in "Baumgaertner's Journal," in 1837, in which the principle of the unity of natural forces and the law of equilibrium, now generally adopted, were for the first time exactly and fully defined, and, five years afterward, were established on a firm mathematical basis by Robert Mayer, of Heilbronn, and, still later and more fully, by the experimental researches of Joule, in England.*

His application to practical pharmacy led Mohr to again enter the field of pharmaceutical and chemical research; he undertook the completion of the comprehensive work "Pharmacopœia Universalis," projected by Professor P. L. Geiger, who died in 1836, shortly after the publication of the first part of that work, embracing the crude drugs and simple chemicals. The second part, by Mohr, was published in 1845, and contained the formulary of pharmaceutical and chemical preparations of the various European pharmacopœias in use during the preceding seventy-five to eighty years, and including, of American works, the United States Pharmacopœias of 1820 and 1830, Coxe's "American Dispensatory," and Ellis's "Formulary." His application to the details of practical pharmacy and of chemical operations, his wonderful skill and inventive mind, resulted in the improvement and completion of old, and in the construction of a large number of novel

* "Popular Science Monthly," vol. xv., pp. 397–407; ibid., vol. v., pp. 103–107; "Archiv der Pharmacie," vol. 216 (1880).

apparatus, appliances, and processes in pharmacy and chemical analysis, which he embodied in his "Lehrbuch der pharmaceutischen Technik" ("Manual of Pharmaceutical Practice"), published in 1846. This remarkable work has since been reprinted in five editions, and has been twice translated into French, and into English by Professor Redwood, of London, and edited for American use, in 1848, by the late Professor William Procter, Jr., of Philadelphia.

In 1847 Mohr completed a commentary on the Prussian Pharmacopœia in two volumes, a work replete with original research and thought, and characterized by frank critical analysis of both the excellences and the defects of the Prussian standard. This work has also been republished in five editions. A smaller volume on the art of dispensing (Receptir Kunst), mainly intended for the instruction and use of physicians, published in 1854, completes the list of Mohr's separate pharmaceutical works, while his numerous contributions to the pharmaceutical journals of Germany, continued almost during his lifetime, were of great importance, covering the domain of practical pharmacy, and embracing many processes as well as manipulations and apparatus, invented or perfected by him and now widely adopted and in general use everywhere.

The principles and great practical value of the volumetric method of estimation in chemical analysis, recently introduced by Gay-Lussac, Marguerite, and others, attracted at once Mohr's quick and inquisitive mind; recognizing both the simplicity and accuracy of this method, he promptly applied his study and talents to its improvement, and soon brought volumetric analysis to such a perfection and comparatively ready execution that his "Manual of Volumetric Analysis" ("Lehrbuch der chemisch-analytischen Titrirmethode"), published in 1855, met with general and unqualified acceptance; since then four revised and enlarged editions have been published, and it has been translated into most civilized languages, and up to the present time is regarded as the standard work in this branch of chemical analysis, which has been of great value and use in the development and advance of chemical industry.

During these active years of Mohr's life it was, however, not only the practical and analytical application of pharmacy and chemistry that received his attention and the fruits of his labors and accomplishments, but likewise the theory of science and popular instruction; already in 1864 Mohr had established himself as "Privat-Docent" in pharmacy, chemistry, and geology at the University of Bonn, where he was appointed as Professor of Pharmacy and Chemistry in 1867, and where he published in 1868, aside from many scientific as well as popular contributions to journals, his most important work on theoretical chemistry, "The Mechanical Theory of Chemical Affinity," being a continuation and perfection of his first similar essay published in 1837.

At the meeting of the German scientists and naturalists in Bonn, in 1857, Mohr's interest was so much drawn toward the problems of geology that he henceforth devoted much study and research to geological investigations. Besides a series of excellent popular essays in "Westermann's Monatsheften," in 1866 appeared from his fruitful and highly appreciated pen "A History of the Earth," in which he advanced and sustained novel views on the origin of anthracite coal, the deposits of lime in the seas through the agency of plants, the occurrence of magnetic iron in basalt, and of metallic iron in meteorites, etc.

Mohr's works and writings, extending over a wide sphere of the physical and applied sciences, are characterized by strict scrutiny, clearness, and attractiveness; his attainments, learning, and eloquence were widely appreciated; during many years he delivered popular lectures on various branches, or special topics, or problems of chemistry or geology, at Coblentz, Bonn, Cologne, and other cities, and these lectures drew large audiences of the most cultured classes of society; the present accomplished Empress of Germany was, during her many years' residence in Coblentz, among his devoted hearers. His popular essays in "Westermann's Monatsheften" in "Gaea," in the "Cologne Gazette" and other German journals, were ever-welcome literary contributions of the highest order, and also entered largely into the literature of other nations. Distinctions and honors, never courted by his independent and stern character, were not wanting for him, both at home and abroad. Among American societies, the American Pharmaceutical Association and the Philadelphia College of Pharmacy had elected him an honorary member in 1868.

One year before his death, Mohr delivered, on the occasion of the annual meeting of the "German Apotheker Verein" in Coblentz, in September, 1878, his last address to the representatives of his original vocation—an oration which obtained a wide and just fame for its masterly exposition of the past, the present, and the future mutual relations of chemistry, pharmacy, and medicine, and of the accomplishments of pharmacy for the progress and growth of the other two.

Risen like his famous contemporaries Woehler, Heinrich Rose, Wiggers, Liebig, and others, from the ranks of pharmacy, and carried far off from her special sphere by his application and labors during an active career, Mohr again and again betook himself to his alma mater, and, perhaps more than any one of his collaborators contributed to maintain the high place and reputation of German pharmacy in the domain of physical research; and, among the many eminent scholars and investigators of his time whose names adorn the records of advance in sciences and arts, Friedrich Mohr's name will be an imperishable one in the history of pharmacy and of her offspring chemistry.

CORRESPONDENCE.

EVOLUTION IN AMHERST COLLEGE.

Messrs. Editors.

I HAVE the best authority for saying that President Seelye, of Amherst College, is not satisfied with the interpretations which have been put upon his letter to the "Observer," to the effect that "groundless guesses" are not yet taught at this college "as ascertained truths of science," and that the doctrine of the evolution of man, from the monkey or from any of the irrational animals, being in flat contradiction to all the facts of history, is only fit to be left with the sciolists. He is not willing that a wrong impression should be given to the public with respect to his attitude toward science in general and the scientific doctrines of evolution in particular; and he claims that it was very far from his intention, in his note to the "Observer," to place his college or himself in antagonism to either. It is only just to him, therefore, that he should be set right. I am authorized to say that he has long "firmly believed the current doctrine of evolution to contain a great truth, as well as a subtile error." Moreover, he maintains that "all great truths, whether styled evolution or otherwise, so far as they are truly scientific, are taught and encouraged at Amherst; that all investigations of science and all earnest efforts to widen the field of our knowledge find a cordial welcome there. In a word, that evolution, cosmological and biological, so far as it is scientific, is taught as a part of science; but that such atheistic, illegitimate, unscientific conclusions or assumptions as may apparently flow from certain unwarranted expositions of the law of evolution, together with all other illogical, irrational, and unscientific conclusions and dogmatic deliverances constitute the 'groundless guesses' and the 'subtile error'" to which he referred—"and that these find no favor at Amherst." President Seelye gives his unqualified assent to and adopts this statement of his own, and the position of the college, and thinks its publication will do good.

Besides, it appears that Le Conte's "Geology" was specially recommended by the President to the Professor of Geology as a text-book for his class before its introduction, and after a careful examination of the work. Moreover, that the new department in biology was introduced to the college through President Seelye's own proposal and urgency with the trustees, and this because he desired the college to have the best and largest teaching in so important a field; also that he turned the attention of the present instructor in biology in that particular line, and sent word to him while in Germany that he should especially make the acquaintance of Haeckel and his work. The President considers that he would be unworthy of his place if he were indifferent to or intolerant of the investigations of science, and expresses himself as the reverse of hostile to free thinking.

No lover of science can find any fault with the position of President Seelye in its new aspect, and it is certainly a matter for regret that he has been placed at all in a false or equivocal attitude. Of course, no one who knows him can for an instant entertain the thought that he intended to mislead or supposed he would mislead by his former statement.

Upon such a platform, if faithfully adhered to and its declarations rigorously carried out, and under such leadership, Amherst will certainly be entitled to a high place among those institutions of broad and thorough culture and catholicity of sentiment of which Harvard and the Johns Hopkins University are prominent examples—institutions which inspire confidence in American scholarship at home and give it character abroad. And the evolutionists at Amherst, who are working in their special departments, are to be most heartily congratulated that, unlike their less fortunate brethren at Yale, *they* at least have no one more ready to support them and lead them forward than the President of their own college, who says it is his "full belief that there was never more or better scientific instruction given in Amherst than now."

DANIEL G. THOMPSON.

NEW YORK CITY, *May* 20, 1880.

CRAYFISH FOR STUDY.

Messrs. Editors.

A CLASS of about ten of our teachers has been meeting once a week this term, and, with Professor Huxley's book in one hand and a crayfish in the other, we have endeavored to verify the statements of the book.

After reading your notes on the distribution of the animal in North America, the thought occurred to me that it might be a favor to some students to know where a supply could be had. If you think it will

help along the study of natural history, you may say that I can furnish any reasonable number at a cost of, say, two cents each, which I would have to pay boys for collecting. Yours truly,

E. A. GASTMAN,
Superintendent of Schools.

DECATUR, ILLINOIS, *May* 18, 1880.

ANIMAL AFFECTION.

Messrs. Editors.

A STORY recently related to me regarding a remarkable display of affection in a pet monkey is so similar to one which I have just read in "The Popular Science Monthly" for March, that I am induced to send it to you as corroborative of the truth or probability of the latter.

An officer of the United States Revenue Marine Service, and now upon this station, informs me that several years ago he owned a monkey which was very intelligent, and became exceedingly fond of him. Returning home one day after a brief absence, the officer saw that the monkey was unwell, but could not account for its illness. It seemed to be in great suffering, but at the same time showed its joy at seeing his master. The latter raised him in his arms, and the monkey, taking him by each of his whiskers, looked into the face of his human friend and kissed him two or three times. After he had done this, the monkey fell back and died almost immediately.

It is reasonable to suppose that the animal had some knowledge of his approaching end, and intended his embrace as a final farewell to his master. The subject of the intellectual capacities of animals is too large a one for the limits of this letter; I will, therefore, do no more than call your attention to this instance of almost human feeling.

E. H. N.

PORT TOWNSEND, WASHINGTON TERRITORY, *May* 8, 1880.

EDITOR'S TABLE.

GOETHE AND THE ARTISTIC STUDY OF NATURE.

GOETHE, the German poet, was the author of a work, in two volumes with an atlas, on the subject of colors, in which he put forth an elaborate theory of his own upon that subject. It appears that fragments only of this treatise have been translated into English, and, as its views have never attracted much attention or become generally known, Professor Tyndall has done well in recently devoting a lecture to an account of them. We print this admirable address, which our readers will be sure to find entertaining and instructive. For, though the doctrines put forth by Goethe on chromatics are not in themselves important and have no rank as contributions to the science of color, yet they have an interest as the products of a genius now everywhere confessed, though as yet but imperfectly interpreted by the critics. That he was a man of a many-sided nature, of perfected culture, and in various lines of a lucid insight, is not to be denied; and these traits give great importance to the problem of the workings of his mind in whatever direction it was systematically exercised. The poet Bayard Taylor, the successful translator of "Faust," declared that he considered Goethe "to have had the most grandly-proportioned and full-orbed intellect that has yet appeared among men"; but Professor Tyndall is inclined to rank him, on the contrary, among those who may be described as mental "hemispheres; or, at least, spheres with a segment sliced away—full-orbed on one side, but flat upon the other." In what this incompleteness consisted is clearly shown in Professor Tyndall's address. Goethe's mental pre-eminence was on the æsthetic, imaginative, and literary side, and this so predominated as to disqualify him from entering into the true scientific method of the study of Nature. He held to the competency of poetic and artistic insight alone to discern the truth in natural things; he tried it, and achieved a partial success, which naturally confirmed

the idea. He then undertook to carry out his method systematically in a chosen field, and failed so conspicuously as not only to settle the question against him, but to make his failure a landmark of modern intellectual history. The chief interest of the subject is, therefore, by no means the question of the status of Goethe; it is a question of the claims of antagonist methods in the views to be taken of the surrounding world.

The view ineffectually maintained by Goethe by no means fell with his failure; it had been too long and too firmly established. The poetic and artistic method of regarding Nature was the earliest; and it was inevitable that the mental procedures it involved should become the universal habit and the basis of culture. It was the all-accepted and all-sufficient mode of viewing the natural order. The poet and the painter pictured the world as presented to the senses and the feelings. Philosophy worked out, and theology enforced, the first rude interpretations of natural objects and events, as they were open to the observation of the senses. Literature, of course, embodied those current modes of thought which were occupied merely with the external aspects of things, and such interpretations as were possible with only this surface-knowledge.

This method was satisfactory for many ages; but there at length began to grow up a curiosity or desire to pry into things and see what would come of it. Men began to penetrate beneath the superficial show to the subtiler structures and underworking forces by which all appearance is determined. Thus science arose. It began in dissatisfaction with the shallowness of the knowledge of Nature and the insufficiency of its current explanations; and it began at the outset to devise new means of arriving at truth. Instruments of scrutiny, instruments of analysis, experiment, and dissection, were devised, and, by their diligent application, curious and startling revelations were made of the inner workings, the finer constitution, and the deeper harmonies of the surrounding universe.

This new procedure of science the poets and artists have ever been inclined to resent as a violence and desecration. Accepting Nature as disclosed to the senses, and interpreted by immediate intuitions, they oppose science as a heartless agency, inappreciative of beauty, and destructive of poetry and art. Goethe strongly shared this jealousy of science as an intrusive rival of the great arts that have enriched the life of man. He was not only a representative poet, powerfully dominated by æsthetic feeling and artistic sentiment, but he was also a philosophic thinker, and not without some scientific aptitude, and with these qualifications he was ambitious of becoming the champion of artistic and poetic ideals against the cold and ruthless processes of experimental science. He chose a branch of optics as the field of conflict, and Newton as his antagonist, with what result Professor Tyndall's paper sufficiently indicates. Professor Helmholtz, some years ago, gave a lecture "On Goethe's Scientific Researches," in which he treats his character and labors from the point of view here taken. We subjoin some passages from this instructive discourse:

> Goethe, though he exercised his powers in many spheres of intellectual activity, is nevertheless, *par excellence*, a poet. Now, in poetry, as in every other art, the essential thing is to make the material of the art, be it words, or music, or color, the direct vehicle of an idea. In a perfect work of art, the idea must be present and dominate the whole, almost unknown to the poet himself, not as the result of a long intellectual process, but as inspired by a direct intuition of the inner eye, or by an outburst of excited feeling.
>
> An idea thus embodied in a work of art, and dressed in the garb of reality, does indeed make a vivid impression by appealing directly to the senses, but loses, of course, that universality and that intelligibility which it would have had if presented in the form of an abstract notion. The poet, feeling how

the charm of his works is involved in an intellectual process of this type, seeks to apply it to other materials. Instead of trying to arrange the phenomena of Nature under definite conceptions, independent of intuition, he sits down to contemplate them as he would a work of art, complete in itself, and certain to yield up its central idea, sooner or later, to a sufficiently susceptible student. Accordingly, when he sees the skull on the Lido, which suggests to him the vertebral theory of the cranium, he remarks that it serves to revive his old belief, already confirmed by experience, that Nature has no secrets from the attentive observer. So, again, in his first conversation with Schiller on the "Metamorphosis of Plants." To Schiller, as a follower of Kant, the idea is the goal, ever to be sought, but ever unattainable, and therefore never to be exhibited as realized in a phenomenon. Goethe, on the other hand, as a genuine poet, conceives that he finds in the phenomenon the *direct expression* of the idea. He himself tells us that nothing brought out more sharply the separation between himself and Schiller. This, too, is the secret of his affinity with the natural philosophy of Schelling and Hegel, which likewise proceeds from the assumption that Nature shows us by direct intuition the several steps by which a conception is developed. Hence, too, the ardor with which Hegel and his school defended Goethe's scientific views. Moreover, this view of Nature accounts for the war which Goethe continued to wage against complicated experimental researches. Just as a genuine work of art can not bear retouching by a strange hand, so he would have us believe Nature resists the interference of the experimenter who tortures her and disturbs her; and, in revenge, misleads the impertinent kill-joy by a distorted image of herself.

Accordingly, in his attack upon Newton, he often sneers at spectra, tortured through a number of narrow slits and glasses, and commends the experiments that can be made in the open air under a bright sun, not merely as particularly easy and particularly enchanting, but also as particularly convincing!

We have seen that Goethe rebels against the physical theory just at the point where it gives complete and consistent explanations from principles once accepted. Evidently it is not the insufficiency of the theory to explain individual cases that is a stumbling-block to him. He takes offense at the assumption made for the sake of explaining the phenomena, which seem to him so absurd, that he looks upon the interpretation as no interpretation at all. Above all, the idea that white light could be composed of colored light seems to have been quite inconceivable to him; at the very beginning of the controversy, he rails at the disgusting Newtonian white of the natural philosophers, an expression which seems to show that this was the assumption that most annoyed him.

To give some idea of the passionate way in which Goethe, usually so temperate and even courtier-like, attacks Newton, I quote from a few pages of the controversial part of his work the following expressions, which he applies to the propositions of this consummate thinker in physical and astronomical science: "Incredibly impudent"; "mere twaddle"; "ludicrous explanation"; "admirable for school-children in a go-cart"; "but I see nothing will do but lying, and plenty of it."

Thus, in the "Theory of Color," Goethe remains faithful to his principle that Nature must reveal her secrets of her own free will; that she is but the transparent representation of the ideal world. Accordingly, he demands, as a preliminary to the investigation of physical phenomena, that the observed facts shall be so arranged that one explains the other, and that thus we may attain an insight into their connection without ever having to trust to anything but our senses. This demand of his looks most attractive, but is essentially wrong in principle. For a natural phenomenon is not considered in physical science to be fully explained until you have traced it back to the ultimate forces which are concerned in its production and its maintenance. Now, as we can never become cognizant of forces as forces, but only of their effects, we are compelled in every explanation of natural phenomena to leave the sphere of sense, and to pass to things which are not objects of sense, and are defined only by abstract conceptions.

But this step into the region of abstract conceptions, which must necessarily be taken if we wish to penetrate to the causes of phenomena, scares the poet away. In writing a poem he has been accustomed to look, as it were, right into the subject, and to reproduce his intuition without formulating any of the steps that led him to it. And his success is proportionate to the vividness of the intuition. Such is the fashion in which he would have Nature attacked. But the natural philosopher insists on transporting him into a world of invisible atoms and movements, of attractive and repulsive forces, whose intricate actions and reactions, though governed by strict laws, can scarcely be taken in at a glance. To him the impressions of sense are not an irrefraga-

ble authority; he examines what claim they have to be trusted; he asks whether things which they pronounce alike are really alike, and whether things which they pronounce different are really different; and often finds that he must answer, no! The result of such examination, as at present understood, is that the organs of sense do indeed give us information about external effects produced on them, but convey those effects to our consciousness in a totally different form, so that the character of a sensuous perception depends not so much on the properties of the object perceived as on those of the organ by which we receive the information.

We see that science has arrived at an estimate of the senses very different from that which was present to the poet's mind. And Newton's assertion that white was composed of all the colors of the spectrum was the first germ of the scientific view which has subsequently been developed. For at that time there were none of those galvanic observations which paved the way to a knowledge of the functions of the nerves in the production of sensations. Natural philosophers asserted that white, to the eye the simplest and purest of all our sensations of color, was compounded of less pure and complex materials. It seems to have flashed upon the poet's mind that all his principles were unsettled by the results of this assertion, and that is why the hypothesis seems to him so unthinkable, so ineffably absurd. We must look upon his "Theory of Color" as a forlorn hope, as a desperate attempt to rescue from the attacks of science the belief in the direct truth of our sensations. And this will account for the enthusiasm with which he strives to elaborate and to defend his theory, for the passionate irritability with which he attacks his opponent, for the overweening importance which he attaches to these researches in comparison with his other achievements, and for his inaccessibility to conviction or compromise.

In conclusion, it must be obvious to every one that the theoretical part of the "Theory of Color" is not natural philosophy at all; at the same time we can, to a certain extent, see that the poet wanted to introduce a totally different method into the study of Nature, and more or less understand how he came to do so. Poetry is concerned solely with the "beautiful show" which makes it possible to contemplate the ideal; how that show is produced is a matter of indifference. Even Nature is, in the poet's eyes, but the sensible expression of the spiritual. The natural philosopher, on the other hand, tries to discover the levers, the cords, and the pulleys, which work behind the scenes, and shift them. Of course, the sight of the machinery spoils the beautiful show, and therefore the poet would gladly talk it out of existence, and, ignoring cords and pulleys as the chimeras of a pedant's brain, he would have us believe that the scenes shift themselves, or are governed by the idea of the drama. And it is just characteristic of Goethe that he, and he alone among poets, must needs break a lance with natural philosophers. Other poets are either so entirely carried away by the fire of their enthusiasm that they do not trouble themselves about the disturbing influences of the outer world, or else they rejoice in the triumphs of mind over matter, even on that unpropitious battle-field. But Goethe, whom no intensity of subjective feeling could blind to the realities around him, can not rest satisfied until he has stamped reality itself with the image and superscription of poetry. This constitutes the peculiar beauty of his poetry, and at the same time fully accounts for his resolute hostility to the machinery that every moment threatens to disturb his poetic repose, and for his determination to attack the enemy in his own camp.

But we can not triumph over the machinery of matter by ignoring it; we can triumph over it only by subordinating it to the aims of our moral intelligence. We must familiarize ourselves with its levers and pulleys, fatal though it be to poetic contemplation, in order to be able to govern them after our own will, and therein lies the complete justification of physical investigation, and its vast importance for the advance of human civilization.

"*EVOLUTION ADMITTED, WHAT THEN?*"

It is gratifying to note an obvious subsidence of alarm on the part of eminent divines in regard to the acceptance of evolution doctrines, accompanied by the bolder enunciation of rational views respecting religion. Dr. E. O. Haven, Chancellor of the University of Syracuse, and now a Methodist bishop, sends a communication to a leading religious journal under the above title, which is full of significant foreshadowings that are worthy of notice.

Dr. Haven utters a very important truth when he says: "Men are prone to associate their religion with its drapery. This becomes obsolete and must

be changed, and the looker-on fancies that the very body and soul are gone." This is the view of science. Religion, like other things, is progressive, and proceeds from stage to stage, successively molting its integuments with increasing expansion and a higher life, or, by the figure of Dr. Haven, shedding its worn-out clothing as occasion requires. It is a great point gained in this matter to discriminate between the living body and its accidental and temporary wrappings—between perennial truth and its obsolete accompaniments. The credal habiliments are not the vital thing they invest, and to cling to them as if they were is superstition. Dr. Haven's point of view enables us to appreciate the triviality of denominational cuts, fits, and styles; and illustrates the futility of venerating theological rags and tatters instead of the essential religious ideas which require ever to be clothed anew as men grow in grace. And what a pitiful spectacle, moreover, it is to see people so confused and perverted in their notions as to actually worship the heaps of old clothes that have been long ago worn out and cast off!

We are glad to observe that Bishop Haven does not recoil from the conception of creation as a continuous, ever-unfolding work. He wisely accepts the view of God, compelled by evolution, as that of an eternally-creating Spirit. He says, "Is there any reason whatever to believe that God at any past period, large or small, had any more or less to do than now with this earth and all that it contains?" And again: "Had we all been educated in a theory of gradualism and constancy and improvement, and thoroughly saturated with it, and yet aroused into a profound belief in God, as is certainly conceivable on that theory, and then, should the theory of a Deity sometimes awake and sometimes asleep be suggested, it would shock some feeble minds into atheism." But would not strong minds also be thus shocked, and justly so; and would not the atheism be real? When evolution has become an established and familiar idea in the religious world, and the Creative Power is conceived—as far as such conception is possible to finite faculties—as the mighty, ever-energizing spirit of which the boundless universe is but the manifestation, a reversion to present current notions of the method of creation will assuredly be regarded as a lapse into atheistic paganism, analogous to a present backward plunge into fetichism.

LITERARY NOTICES.

PREADAMITES; OR A DEMONSTRATION OF THE EXISTENCE OF MAN BEFORE ADAM; TOGETHER WITH A STUDY OF THEIR CONDITION, ANTIQUITY, RACIAL AFFINITIES, AND PROGRESSIVE DISPERSION OVER THE EARTH. With Charts and other Illustrations. By ALEXANDER WINCHELL, LL. D., Professor of Geology and Paleontology in the University of Michigan. Chicago: S. C. Griggs & Co. Pp. 500. Price, $3.50.

THE views of Dr. Winchell on the subject of preadamites, which he put forth some time ago in a modest pamphlet, to which we drew attention, he has now matured and brought out in a very handsome and richly illustrated volume. We have been more than pleased with a somewhat critical perusal of it. The work is popular in its best sense—attractive in style, clear in exposition, and eminently instructive in its subject matter. Though drawing its facts from wide sources, it is far from being a mere compilation; it is dominated by a large, original purpose, which is kept steadily in view throughout the whole course of its close and trenchant argument.

Dr. Winchell's book has a double interest which should not be overlooked. Though making no claims of this nature, it is yet a valuable exposition of ethnological science, treating instructively a wide range of questions in relation to the origin, distribution, characteristics, and natural history of the human races. These subjects are now of commanding interest. All modern knowl-

edge converges upon this great human research; and "the proper study of mankind" is now more fruitful of positive and pregnant conclusions than it has ever been before. The theme is itself of intrinsic moment to the students of nature, and is engaging the assiduous attention of talented men in all cultivated nations. From this point of view alone, or as a repository of facts and a lucid exposition of principles, the volume has marked merit, and will do excellent service simply as a popular ethnological manual.

But, while useful as a mere didactic discussion of anthropological questions, the work has an interest of another kind in relation to the special object for which it was written. It is an able contribution to a serious modern controversy, which will bring it into demand beyond the customary circle of scientific and miscellaneous readers. The Church has its traditional ethnology, vaguely assented to by multitudes who have never inquired into the subject, but which is now totally out of harmony with all the results of actual knowledge. It is the old astronomical conflict over again, in a more modern field. Knowledge still advances, and stationary, dogmatic beliefs are left standing as milestones to mark its progress. The prevalent ecclesiastical theory of the origin and history of the human race, which is passively entertained by the great body of orthodox believers, must be discarded or squared with the results of scientific investigation. All fair-minded theologians will recognize the significance of the crisis, and welcome every efficient contribution toward the settlement of the difficulty. Dr. Winchell's work is devoted to this object, and it is executed with such learning and ability that it must at once take rank as an authoritative text-book of the subject. It is not too much to say that it settles the controversy; and all Christian teachers, who have any genuine interest in the adjustment of their beliefs so that they shall harmonize with scientific demonstrations, owe gratitude to the author of this work for the untiring labor that he has bestowed upon the inquiry, and the intrepid spirit in which he has pursued it.

The definite scope of Dr. Winchell's book may be best obtained from his own statement. He says: "The central idea of the work is human preadamitism; all other views presented are subsidiary or collateral. The thesis implies that the characterization of Adam, in the document which has given us the name, is such that the name can not be applied to the first progenitor of the human kind, and that all the collateral statements either involve or permit the derivation of Adam from an older race. But the defense of the thesis does not rest, as it once did, on the purely linguistic interpretation of the Bible. We have now the facts of race-histories, and the discovered laws of animal life, past and present, to summon to the sanction and support of the conclusion. I have not contented myself with the employment of the direct argument, but have attempted to show that the old hypothesis of the descent of the black races from Ham is equally unscriptural and unscientific. Finally, assuming the thesis proved, I have endeavored to gratify the natural and intelligent curiosity which expresses itself in the questions: Who, then, were the first men? Where did they appear, and how long since? How have the races come into existence, and what has been the method of their dispersion over the earth? These questions necessarily lead us to the very borders of the field of recognized facts, and even into the domain of speculation; but I hope I have in most cases presented views which coördinate the facts in a rational conception, if I have not enunciated conclusions which will stand the test of future investigation. I hope, also, that on some of these themes I have presented groupings of the facts and tentative generalizations which will interest the strictly scientific inquirer. In any event, I desire the reader to consider that the defense of the main thesis is not involved in any of the hazard of the speculative suggestions brought forward in the sequel."

It is impossible here to enter into any detail of the views developed in this work; but the reader will get a good idea of the nature and breadth of the discussion by an ennumeration of the subjects treated. Dr. Winchell's chapters are: I. "Some Traditional Beliefs"; II. "Biblical Language"; III. "The Hamites and their Dispersion"; IV. "The Semites and their Dispersion"; V.

"The Japhetites and their Dispersion"; VI. "Principal Types of Mankind"; VII. "Limited Scope of Biblical Ethnography"; VIII. "A Glance at Hebrew Chronology"; IX. "Elements of Egyptian Chronology"; X. "Prenoachite Races"; XI. "Race Distinctions"; XII. "Biblical Antiquity of Race Distinctions"; XIII. "More Biblical Antiquity of Race Distinctions"; XIV. "Preadamite Races"; XV. "Hamitic Origin of Negroes considered"; XVI. "Negro Inferiority"; XVII. "Do Races degenerate?"; XVIII. "Theological Consequences of Preadamitism"; XIX. "Genealogy of the Black Races"; XX. "Genealogy of the Brown Races"; XXI. "Genealogy of the White Race"; XXII. "The Cradle of Humanity and the Dispersion of the Black Races"; XXIII. "Dispersion of the Asiatic Mongoloids"; XXIV. "Dispersion of the American Mongoloids"; XXV. "Dispersion of the Dravidians and Mediterraneans"; XXVI. "Condition of Primitive Man"; XXVII. "Antiquity of Man"; XXVIII. "The Patriarchal Periods"; XXIX. "Preadamitism in Literature."

Dr. Winchell's book is got up in elegant form. It contains a large number of beautifully executed illustrations, with some finely worked charts. Press-work and binding are in the best style, doing credit to the enterprise of the publisher and to the proficiency of industrial art in the city where it was produced.

THE LIFE AND WRITINGS OF HENRY THOMAS BUCKLE. By ALFRED HENRY HUTH. New York: D. Appleton & Co. Pp. 502. Price, $2.

THOUGH the career of Buckle was not filled with striking incidents, such as are commonly supposed to be necessary to give interest to biography, it was, nevertheless, of so marked and individual a character that its delineation is certain to prove both instructive and entertaining to a large number of readers. Whatever may be the final verdict as to the value of his intellectual work, Buckle was certainly a power in the thought of his time—a man of force, originality, and independence, so conspicuous as to give significance to the personal particulars of his life. There was much curiosity about him as to who he was, and what had been his history, when he suddenly shot up from obscurity to a brilliant position in literature, and various sketches of him were called forth at the time, although they were meager and unsatisfactory. This volume is the first extended biography of Buckle that has appeared; and, although his intimate friend, Mr. Huth, writes as an ardent admirer, he has endeavored to make a just estimate of his character as a man and a thinker. The volume derives large interest from the considerable correspondence which it reproduces, and which throws much light on the habits, peculiarities, and opinions of the man. Mr. Huth makes an excellent summary of the leading conceptions of Buckle's work, pointing out what seem to be the fundamental conceptions that are due to him, and which it is claimed have largely contributed to place history in the category of the sciences. It may be freely conceded, at any rate, that he did a great service in presenting this view in so captivating a style, and with such a wealth of illustrations, as to make a profound impression upon the popular mind. His "History of Civilization in England" was a liberalizing book, and exerted an educating influence upon multitudes of readers.

Like many other men who have achieved a position and done valuable work, Buckle's early education was out of the common routine which more often cramps than develops. He was, in fact, allowed to do pretty much as he desired with regard to study, and was, therefore, free to follow his own bent. His individuality was but little interfered with, and he was left to the best of all culture—self-culture. The death of his father, when he was but nineteen years of age, left him in easy circumstances, with leisure to pursue his studies in the direction of his chosen life-work. The idea of the history was at first vague in his mind, and grew into more definite shape with advancing years. While yet without experience of the formidable labor before him, he drew up the most ambitious schemes of the history of civilization which he proposed to execute in a series of twenty volumes, but he died at the early age of forty-one, with only a fragment of his great design accomplished. It was a noble purpose to which he consecrated his life, and even in its very partial attainment

he made a contribution to historic inquiry which has been translated into many languages, and influenced in no small degree the thinking of his generation.

Mr. Buckle was, beyond doubt, deficient in many qualities necessary to handle so vast a theme at the period when he entered upon the undertaking. He lacked the scientific preparation for dealing adequately with his task. He was not well equipped with the large ideas which had a bearing upon it, and which were already ripened in leading contemporary minds. When he published his first volume, in 1857, Herbert Spencer had already matured a system of thought, involving the principles of social development, and based upon the new philosophy of evolution. Mr. Buckle was not only unprepared to avail himself of these controlling conceptions, but he resisted some of them as he would not have done if his training had been more thoroughly in the true spirit of science. But he did his work well, and it is fortunate for his memory that the task of delineating his life fell into such excellent hands as those of his present biographer. The book is interestingly written, and will be read with pleasure even by those who know little of the works of the author.

THE FUNDAMENTAL CONCEPTS OF MODERN PHILOSOPHIC THOUGHT, CRITICALLY AND HISTORICALLY CONSIDERED. By RUDOLPH EUCKEN, Ph. D., Professor in Jena. Translated by M. STUART PHELPS, Ph. D., with an Introduction by President PORTER. New York: D. Appleton & Co. Pp. 304. Price, $1.75.

PROFESSOR EUCKEN'S book is not only an important addition to the history of philosophy, but it is an addition that is specially adapted to the requirements of the present time. With great skill and learning, and remarkable clearness of style for a German philosopher, he has traced out the origin and progress of those fundamental conceptions which play so prominent a part in modern controversy, and also of the terms by which those ideas are represented. The author's point of view is tacitly that of evolution, since he undertakes to delineate the philosophical concepts of to-day in their historical formation, and in their transformations, extensions, and shiftings of phraseology. How fitly his discussion answers to the needs of the times will appear from a glance at the contents of his volume, which we subjoin: I. "Subjective and Objective"; II. "Experience"; III. "A Priori—Innate"; IV. "Immanent (Cosmic)"; V. "Monism, Dualism"; VI. "Law"; VII. "Development"; VIII. "Primary Concepts of Causation (Mechanic—Organic) (Ideology)"; IX. "Culture"; X. "Individuality"; XI. "Humanity"; XII. "Realism—Idealism"; XIII. "Optimism—Pessimism"; XIV. "Conclusion."

It will be seen from this enumeration of subjects that the work covers a large field of contemporary interest, both scientific and speculative; but it must not be supposed that the author engages in the positive discussion of these topics as they are now treated by systematic controversialists. Into the present conflict of thought, as the representative of any school, he does not enter; and hardly a great name in the science or philosophy of the present age appears in his pages. But, taking the leading conceptions that are now of special interest in literary and philosophical circles, and which, "proceeding from philosophy and the general scientific development, have become a power in life as a whole," he subjects them to such historical analysis and criticism as will prove serviceable to the modern student.

Dr. Porter recommended this volume for translation, and has at once adopted it as a text-book in Yale College. He contributes to it a brief Introductory Essay, commending it to English readers as eminently suited to the times. "He can say with an assured confidence that there are few books within his knowledge which are better fitted to aid the student who wishes to acquaint himself with the course of modern speculation and scientific thinking, and to form an intelligent estimate of most of the current theories."

CHEMISTRY, INORGANIC AND ORGANIC, WITH EXPERIMENTS. By CHARLES LOUDON BLOXAM, Professor of Chemistry in King's College, London. Fourth edition. Philadelphia: Presley Blakiston. Pp. 688. Price, $4.

BLOXAM'S "Chemistry" has had an excellent reputation as a practical manual for several years; and the present revised edition brings it fairly up to date. The author remarks that some alterations have been

made in the present edition, to bring the theoretical portion into harmony with modern views; but its treatment of chemical theory, although good, is not the strongest feature of the work. Its first claim to consideration, and an important one, is the great number of simple illustrative experiments that it pictures and describes. There is a great profusion of cuts representing apparatus and manipulations, which will be most serviceable to lecturers and chemical workers. Another point of special interest in the work is the prominence it gives to the subject of manufacturing processes. The principles involved in the most important of these are very clearly and fully explained. Professor Bloxam has been long associated with the Government military establishment at Woolwich, and has made many investigations into the properties of explosives. The student will accordingly find that more than usual attention is given to the chemistry of the various substances employed in warlike stores.

PHARMACOGRAPHIA: A History of the Principal Drugs of Vegetable Origin met with in Great Britain and British India. By FRIEDRICH FLÜCKIGER, Ph. D., Professor in the University of Strasburg, and Dan. Hanbury, F. R. S. Second edition. London: Macmillan & Co. (22 Bond Street, New York). 1879. 8vo, pp. 803. Price, $5.

THE second edition of this master-work, first published in 1874 and now revised by the only surviving author, Professor Flückiger, has been long looked for, and is received everywhere with due appreciation. Exceeding the first edition by one hundred pages, it is identical with it in scope and arrangement. The drugs are classified according to their botanical origin, and the natural orders arranged in accordance with the system of De Candolle. The Latin name, with the principal synonyms of each drug, is followed by their English, German, and French names. The main sections of each article treated are: "Botanical Origin," "History," "Collection," "Description," "Microscopic Structure," "Chemical Composition," "Production and Commerce," "Uses, Adulterations, and Substitutes."

The section "Botanical Origin" enumerates the recognized botanical name, together with the synonyms, the habit, and locality of the plant yielding the drug; all strictly botanical descriptions are, very properly, almost entirely excluded. The section "History" is particularly unique and interesting; it gives an historical account of each drug from the time when it was first used, traces its employment by different nations, its influence upon commerce, its value at different periods, cultivation, etc. This is followed by an account of the "Collection" of the drug, and its manufacture for the market, in all such cases where this information is likely to explain its physical properties, which are described under the section "Description," and followed by "Microscopical Structure." In the section "Chemical Composition" the views of different investigators have been carefully sifted, and the results of the most recent researches given. Interesting and valuable information and statistics are found in the division "Production, Cultivation, and Commerce." The section "Adulteration and Substitutes" is brief, since the surest way to detect adulterations, of whatever kind, is to be found in a sufficient familiarity with the leading characteristics of the pure article.

The value of all this information is much enhanced and made specially attractive and interesting by copious reference to original sources, covering a wide and varied scope of both old and recent literature.

If there is any desideratum which the very value of the work suggests, it is the want of illustrations in the sections of "Description" and "Microscopical Structure," for which the authors thus far refer to several standard works, mainly German ones, and which desideratum has been well met in the French translation of the work by Professor de Lanessau, which contains more than three hundred well-executed cuts.

AN INTRODUCTION TO THE PHILOSOPHY OF RELIGION. By JOHN CAIRD, D. D. New York: Macmillan & Co. Pp. 358. Price, $3.

A DISQUISITION upon this subject by the Principal of Glasgow University is sure to have a wide welcome. Dr. Caird is well known as one of the clearest and soundest thinkers of the conservative school of theology. In calm, philosophic temper, in liberality of thought, and in acuteness and force of reasoning, this work is far above

the class to which it belongs, and of which we have had many examples within the last few years. The progress of science gives Dr. Caird no anxiety. He cordially accepts its advanced conclusions, and is not concerned about any modification they may necessitate in the old formulas of belief. He perceives that the issues in which religion is essentially involved lie deep in the foundations of psychology, in the nature of knowledge, and the limits of the knowing faculties; and he accordingly addresses himself to a close, logical examination of this subject. There is nothing flippant in his treatment of it; no bad temper, no abuse, no invective, nothing for controversial effect. He sets an example which many of his brethren would be wise to follow, and we accordingly commend his work.

THE WATERING-PLACES OF GERMANY, AUSTRIA, AND SWITZERLAND, CLIMATIC RESORTS, SANITARIUMS, ETC. By EDWARD GUTMANN, M. D. New York: D. Appleton & Co. 1880. Pp. 331. $2.50.

THE author and publishers of this book deserve the thanks of all those who seek health and recreation at the European watering-places. In language easily understood by all, Dr. Gutmann, who is a resident of New York, has described the medicinal properties of the different waters, whether for bathing or drinking, so that the intelligent reader may clearly perceive not only why he is to visit a particular watering-place, but also how he is to enter upon his treatment when he arrives there, and in what way the restoration of health may be most certainly and quickly attained. Nor has the very important matter of diet and manner of living at the watering-places been forgotten, and ere the patient arrives at his destination he can, by the perusal of this book, which is entertaining as well as instructive, acquaint himself with those rules of life and diet which long experience has shown to be so necessary to insure the full benefit of the treatment. In fine, the stranger is made so well acquainted with the place he is to visit, with its history, its baths and springs, its mode of life, and even its appearance, that he feels himself soon at home, and free from that disagreeable sensation so often experienced by the stranger in a strange land. There is a map on which all the different places mentioned in the book are clearly indicated, as well as the routes by which they may be reached from any of the great European cities, or from each other. Each bathing and watering place has also the character of its springs indicated by a colored line, so that the traveler may see at a glance the nature and properties of the waters of any given place: for instance, the blue line indicates the alkaline; the green, the saline; the yellow, the sulphur; the orange, the iron; the brown, the earthy; and the red, the indifferent waters; while the climatic resorts are indicated by a violet line. In short, with this book in hand, the seeker after health may start from New York, London, or Paris, and, with no other guide, reach easily and safely the proper resort for his ailment, and upon his arrival there be fully prepared to enter intelligently upon the course of diet and treatment. There is a comparative table of the different moneys in use in the countries to be visited, as well as a carefully compiled analysis of the different waters. A most useful feature, too, is the therapeutical recapitulation, in which the author briefly indicates the special uses of the different waters, and cures for the alleviation of the ailments for which they have gained a well-earned reputation. The book is handsomely illustrated by engravings of the principal places mentioned, and is a credit to its publishers as well as to its author, who brings to his work the knowledge gained by years of travel and experience, and an entire familiarity with the places of which he treats. To the physician who has patients to send abroad the book is a valuable aid, and to the invalid seeking health at the European spas it is indispensable.

LIFE: ITS TRUE GENESIS. By R. W. WRIGHT. New York: G. P. Putnam's Sons. Pp. 298. Price, $1.50.

A VIGOROUS orthodox polemic against the "materialist school." It contains much ingenious criticism of modern scientific doctrines, but we are unable to see that it throws much new light on the "True Genesis of Life." It is much easier to show the folly and absurdity of the views put forward by Darwin, Spencer, and others, than to bring forward new theories that shall not be open to criticism.

A HANDBOOK OF HYGIENE AND SANITARY SCIENCE. By GEORGE WILSON, M. A., M. D., and C. M. (Edin.), F. C. S. Fourth edition. Philadelphia: Lindsay & Blakiston. 1880. Pp. 458. Price, $2.75.

IN issuing a fourth edition of his valuable work on hygiene, Dr. Wilson has carefully revised the book and enlarged it by some new matter. A new introductory chapter, giving a brief sketch of the progress of sanitary science, has been substituted for that in the previous editions. The work considers a large number of subjects, giving the latest and most authentic knowledge in an interesting form.

The subject of food is considered very fully with regard to its function, constituents, nutritive value, relation to work, and its effects upon public health when it is insufficient or unwholesome. Under this head are also considered the value of preserved foods, the comparative value of different kinds of food, and the construction of dietaries. Air, its impurities and their effects upon public health; the conditions of warming and ventilation; water and its impurities, sources of pollution and modes of detection; the removal of sewage, its purification and utilization; together with a large amount of other matter bearing upon the general question of healthy living, make up the contents of this very excellent treatise. Dealing with subjects of such prime importance to the family, it should find a place in every household.

A HANDBOOK OF DOUBLE STARS. With a Catalogue of Twelve Hundred Double Stars, and Extensive Lists of Measures. With Additional Notes bringing the Measures up to 1879. For the Use of Amateurs. By EDWARD CROSSLEY, F. R. A. S.; JOSEPH GLEDHILL, F. R. A. S.; and JAMES M. WILSON, M. A., F. R. A. S. New York: Macmillan & Co. Pp. 464. Price, $6.

THIS work is intended to facilitate the labors of future students of sidereal astronomy, by supplying the materials for the study of double stars in a convenient form, and as complete as its painstaking authors could make it. It has arisen out of their wants as students, as there does not exist any other book which gives information sufficiently detailed to be of value to any one who seriously takes up this study. The student must hunt through scores and hundreds of volumes if he wishes to get an accurate and complete list of the previous measures of any particular double star. These measures are scattered up and down the astronomical periodicals of all nations; and if he desires to know with what instruments, with what apertures, and what micrometers, these measures were taken, a fresh research awaits him. And, if he proceeds to attempt an orbit, he will fail unless he is a tolerably expert mathematician, for want of sufficient guidance and detail in the various mathematical papers and pamphlets that have been devoted to this subject. The authors express the hope that this manual will be of use in guiding amateurs in their work, in pointing out what stars are of especial interest, what stars have had few or conflicting measures taken of them, at what times observations of certain stars are especially needful, and what stars have been so frequently and satisfactorily measured that for the present they need no attention. The work is appropriate to the present time, as there has been great activity in this field of observation during the last six or seven years. It embodies the results of an immense amount of careful and accurate labor, and can not fail to be of much use to practical astronomers.

PAY HOSPITALS AND PAYING WARDS THROUGHOUT THE WORLD. By HENRY C. BURDETT. Philadelphia: Presley Blakiston. 1880. Pp. 169. Price, $2.25.

THIS is a consideration of the hospital systems of the world, with a view to showing the advantages of pay hospitals and pay wards in general charitable hospitals. In England the system is to have only charitable hospitals, and this results in depriving large classes of the great advantages of a well-appointed medical institution, while at the same time allows many, who can afford to pay for treatment, to obtain it gratuitously. Mr. Burdett states that from thirty to sixty per cent. of those who receive out-door relief are not fit subjects for charity, while a smaller but still considerable percentage of those who are treated within a hospital belong to the same class. He thinks that a stricter inquiry should be made into the circumstances of those applying for charitable relief, confining the advantages of such in-

stitutions to the really needy; and that for the accommodation of all others pay wards, or separate pay institutions, should be provided. He makes a review of the hospitals working successfully on this basis in other countries, to show both the feasibility and desirability of such institutions in England.

A KEY TO GHOSTISM: SCIENCE AND ART UNLOCK ITS MYSTERIES. By Rev. THOMAS MITCHELL. New York: S. R. Wells & Co. Pp. 249. Price, $1.25.

THE author of this volume professes to discredit the supernatural element of modern spiritualism, and to explain all its effects naturally. He holds to clairvoyance and animal magnetism, and accounts for everything of the kind by those agencies. There does not seem to be much gained. Of the science of the book we can not speak very highly. A story is told of a woman suspended horizontally in mid-air, with her head resting upon her arm, and her arm resting upon the the top of a rod. "The lady weighs about one hundred and thirty pounds; and, while thus suspended, the attraction of gravitation is completely overcome. Were the rod upon which her head rests fastened into a scale, she would not probably weigh twenty pounds." Indeed, it is declared that all supports have been removed, "and she left hanging in the air without touching an object; in which case, of course, she would weigh nothing. . . .

"The science of this phenomenon we have already explained. Gravity consists in the attraction of the atmosphere to the earth, and by it. This is called atmospheric pressure, which is fifteen pounds to the square inch. The bulk and density of the earth being so much greater than those of the atmosphere, give all bodies on its surface this superior attractive force to the earth. . . .

"In order to suspend this woman, it was necessary to charge her with electricity or magnetism, fifteen times higher than that of her normal condition. This makes her as positive as the earth itself; and, as two positives resist each other, she hangs in the air just where she is placed. Now, if she should be charged higher than this degree, say sixteen pounds to the square inch, she would, of herself, without a touch, rise from the floor to the ceiling, or to that locality where she would be in equilibrium with the attractive force of the air; and, until demagnetized, would there remain suspended."

And of such is the "Key to Ghostism."

COMMON MIND TROUBLES, AND THE SECRET OF A CLEAR HEAD. By G. MORTIMER-GRANVILLE, M. D. Edited, with Additions, by an American Physician. Philadelphia: D. S. Brinton. Pp. 185. Price, $1.

THIS volume is a reprint of two English primers dealing with kindred topics, which may very well go together. There are many valuable hints in it regarding the care and management of the mind, but the author seems foolishly nervous lest somebody should take him for a materialist. As the main practical facts are independent of speculation, why should he take pains to put himself forward as a theorist and a partisan? Dr. Granville, however, has given much attention to the subject of mental diseases.

DWELLING-HOUSES: THEIR SANITARY CONSTRUCTION AND ARRANGEMENT. By Professor W. H. CORFIELD, A. M., M. D. Van Nostrand's Science Series. New York: D. Van Nostrand. Pp. 156. Price, 50 cents.

THIS is a small volume of lectures reprinted from "Van Nostrand's Magazine," which will well repay attention to those concerned about the hygiene of house-construction. The subject is of deep and increasing interest; Professor Corfield is an authority upon it, and he is content with a plain, common-sense statement of the subject. His lectures refer to English practice, but the principles he expounds are applicable everywhere, and if followed in this country would be productive of much advantage both private and public.

OUR HOMES. By HENRY HARTSHORNE, A. M., M. D. Philadelphia: Presley Blakiston. 1880. Pp. 149. Price, 50 cents.

THIS is one of the series of "American Health Primers" and is an excellent and concise statement of the conditions to be fulfilled in order to have a healthy home. The subjects considered are the site, the

construction of the house, the means of lighting, warming, and ventilating it, and the water supply, drainage, and disinfection. There are also short chapters upon the population that, from a health point of view, should live in any given space, and on workingmen's homes.

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Modern Abuse of Gynæcology. By Clifton E. Wing, M. D. Boston. Pp. 8.

Effects of Mixture of Races on Human Progress. By Professor Joseph Le Conte. Reprint from "Berkeley Quarterly." 1880. Pp. 24.

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The Sulcus Rolando and Intelligence. By S. V. Clevenger, M. D. Illustrated. Chicago: J. J. Spalding & Co., Printers. 1880. Pp. 23.

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Astronomical Approximations. IV. Nodal Estimation of the Velocity of Light. V. Cometary Paraboloids. VI. Cosmical Determination of Joule's Equivalent. By Pliny E. Chase, LL. D., Professor of Philosophy in Haverford College.

Caries of the Ankles in Children. By V. P. Gibney, A. M., M. D. New York: W. Wood & Co. 1880. Pp. 26.

The "North American Entomologist." Edited by Professor A. R. Grote. An Illustrated Monthly for the Use of Students and Agriculturists. Buffalo, N. Y.: Reinecke & Zesch. Pp. 8. $2 a year.

The Masterful Ego, or Mind considered from a Purely Physical Standpoint. By W. D. Wilson. Ithaca: Andrus & Church. 1880. Pp. 8.

The Recession of the Falls of St. Anthony. By N. H. Winchell, State Geologist of Minnesota. Pp. 16. Illustrated.

Address of Professor S. P. Langley, Vice-President Section A., before the American Association for the Advancement of Science, at the Saratoga Meeting, August, 1879. Salem, 1879. Pp. 15.

Cerebral Topography. By S. V. Clevenger, M. D. Reprint from "Journal of Nervous and Mental Disease," October, 1879. Pp. 27.

Report of the Board of Commissioners of the Seventh Cincinnati Industrial Exhibition, 1879. Cincinnati: "Times" Printing Establishment. 1880. Pp. 408.

Proceedings of the Davenport Academy of Natural Sciences. Vol. II., Part II. July, 1877–December, 1878. Davenport, Iowa: J. D. Putnam. 1880. Pp. 356. Illustrated.

Twelfth and Thirteenth Annual Reports of the Trustees of the Peabody Museum of American Archæology and Ethnology. Vol. II. Nos. 3 and 4. Cambridge, 1880. Pp. 311. Illustrated.

The Coming Crisis. San Francisco: A. L. Bancroft & Co., Printers. 1879. Pp. 136. $1.

Problems in Relation to the Prevention of Disease. By J. R. Weist, A. M., M. D. Annual Address of the President of the Indiana State Medical Society. Richmond, Indiana: Telegraph Printing Co. 1880. Pp. 25.

Our Home: a Monthly Magazine. New York: George H. Bladworth & Co. No. 1. January, 1880. Pp. 28. $1 a year.

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Hygienic and Therapeutic Relations of House Plants. By J. M. Anders, M. D., Ph. D. Philadelphia: Printed by J. B. Lippincott & Co. 1880. Pp. 16.

"On the Ghosts in Rutherford's Diffraction-Spectra," and "A Quincuncial Projection of the Sphere." By C. S. Peirce. Reprinted from the "American Journal of Mathematics," Vol. II. 1879.

"Note on the Theory of the Economy of Research," and "Measurements of Gravity at Initial Stations in America and Europe." By C. S. Peirce. Appendices Nos. 14 and 15 to "United States Coast Survey Report of 1876." Washington: Government Printing-Office. 1879.

Multiplication and Division Table, containing the Products of Numbers between 1 and 100. For the Use of Accountants, Computers, and Teachers. By Leonard Waldo, S. D. New York: John Wiley & Sons. 1880.

The Management of Children in Sickness and in Health. By Anne M. Hale, M. D. Philadelphia: Presley Blakiston. 1880. Pp. 110. 50 cents.

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The Metric System. By D. Beach, Jr., and E. A. Gibbens. New York: G. P. Putnam's Sons. 1880. Pp. 62. 75 cents.

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Health and Healthy Homes: A Guide to Domestic Hygiene. By George Wilson, M. A., M. D. With Notes and Additions, by G. J. Richardson, M. D. Philadelphia: Presley Blakiston. 1880. Pp. 307. $1.50.

The Field Engineer: A Handy-Book of Practice in the Survey, Location, and Track-work of Railroads. By William F. Shunk, C. E. New York: D. Van Nostrand. 1880. Pp. 325. $2.50.

Hints and Helps for National Guardsmen. By Colonel William H. Roberts. New York: D. Van Nostrand. 1880. Pp. 228. $1.25.

A Practical Treatise on Sea-Sickness. By George M. Beard, M. D. New York: E. B. Treat. 1880. Pp. 74. 50 cents.

Water Analysis for Sanitary Purposes. By E. Frankland, F. R. S. Philadelphia: Presley Blakiston. 1880. Pp. 149. $1.

The Hysterical Element in Orthopædic Surgery. By Newton M. Shaffer, M. D. New York: G. P. Putnam's Sons. 1880. Pp. 66. $1.

POPULAR MISCELLANY.

The Sanitary Problems of New York City.—Professor W. P. Trowbridge, discussing "The Sanitary Problems of New York City," in the "School of Mines Quarterly," considers chiefly the ventilation of houses and the condition of the streets. The topography of the city, presenting long rows of closely built blocks of dwellings and stores, and of the narrow streets that separate them, is a very obvious sign of the close crowding of a large population into a small space which actually exists. This crowding is of itself a great sanitary evil. If, says Professor Trowbridge, we may take a lesson from nature in the distribution of other classes of the animal kingdom, we find that the herding together in confined places of any one class of animals is detrimental to the health and well-being of the individuals. Diseases peculiar to the class of animals are apt to arise, and a general physical deterioration takes place. "As an animal, man is not exempt from this law of nature, unless, through his own superior intelligence, he secures to himself immunity from the evils which over-crowding entails." A momentous question in our city life is whether, in the construction of our houses, and stores, and hotels, and public halls, the quantity of air which each person requires for his health is provided for by processes or appliances of ventilation. The quantity of air required for a healthy life is generally estimated by the number of cubic feet needed for respiration alone. This is a mistake. Each person needs vastly more—enough to secure a thorough aëration of his clothing and to destroy by oxidation all the hurtful emanations of the body. In houses, moreover, the needs of large quantities of pure air for the aëration of clothing, basements, kitchens, closets, and the closets in which clothing is kept, are probably as great as for respiration. Yet, "how few of the houses in the long blocks which constitute the city of New York have been constructed with the slightest reference to the constant introduction and removal of air!" All of our houses are provided with four or five chimney-flues which might be made available for ventilation to a certain extent, but in the use of which it is so little thought of that the rooms, that might be connected with them, are hermetically sealed from them. The kitchen or basement, where there is necessarily an accumulation of deleterious gases, or impoverished air, is perhaps the worst ventilated room in the house. The people still need to be convinced that ventilation is necessary, and that force must be used to move the air. The object can be secured by means of vertical ventilating flues of sufficient suction, but the application of heat either by a gas-jet or other artificial means is requisite to keep them in operation. The matter of the dirt in the streets has an important sanitary aspect. From this point of view, Professor Trowbridge thinks it is worthy of consideration whether an entirely new treatment is not advisable. Heretofore, attention has been confined to the removal of the dirt as it accumulated; Professor Trowbridge would have means adopted to prevent its accumulating. "The dirt that covers the streets as they are now paved does not come entirely from above or from any external source, but is forced upward from beneath the pavements by the impact of the trucks, carts, carriages, and horses' hoofs, in the ordinary traffic of the city. It is doubtful whether it is possible to keep the streets reasonably clean, even with an expenditure of double the present outlay for that purpose. The soil on which the pavements are laid is not a soil which effects its own drainage, and each successive shower or storm saturates the surface beneath the paving, the water carrying down the leachings of the streets; and this soil, permeated with decomposing substances and saturated with polluted water, is forced to the surface. No better medium for retaining and giving off malarial gases could probably be manufactured. When dried, this expelled mud becomes dust, and is carried about by the winds into every household. The real cure of this great evil appears to me to be an impervious pavement — an asphaltic pavement." No dirt could rise through this, and, if every street in the city were paved with it, what dirt falling upon it was not carried off naturally by showers into the sewers could be thoroughly removed by mechanical sweepers without dust or noise.

The resulting purity of the surface of the streets would have an excellent æsthetic effect upon the population, particularly on those who live in the dirty streets, and would prompt them to purify their own homes, make them pleasant and adorn them —works from which they are now discouraged by the public filth that surrounds them, and which they can not help. Other sanitary improvement would follow the general adoption of these pavements, in the relief from nervous disorders which would be gained by the cessation of the noise of the stone pavements and the worry from their dust and joltings. "The time has come when the sanitarian must extend his field even beyond mere physical causes of disease, and look to the palliation of the effects of incessant struggles and conflicts which a business man of the present day must undergo. . . . Quieting influences are worth almost any price, and these should be sought and provided along with those which relate to physical health."

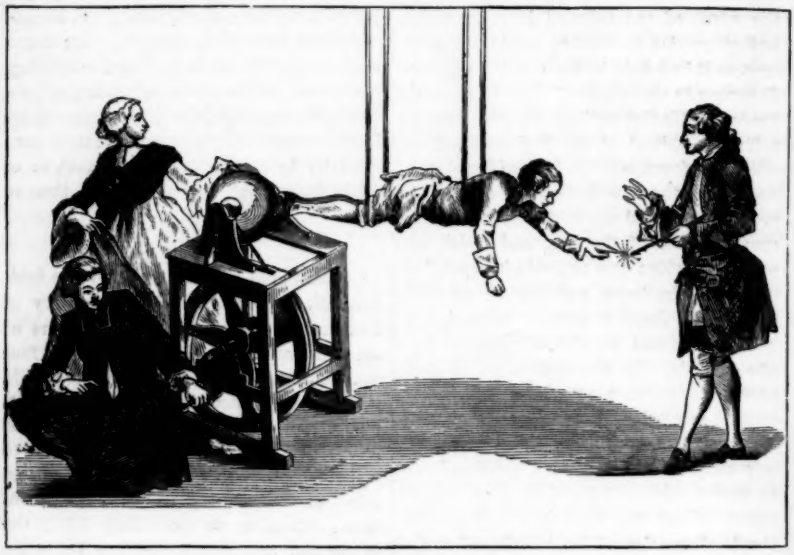
Origin of Domestic Dogs. — Professor Huxley, in the second of two lectures on dogs which he recently delivered at the Royal Institution, examined the peculiarities of the animals of the dog kind, and pointed out that the only respect in which the varieties presented any very great or remarkable difference, apart from the color of the skin or fur and other minor details, was in the structure of the skull and in the teeth. The form of dog which departed most widely from the rest in its dentition was the octocyon, a small, fox-like creature belonging to South Africa, which had forty-eight teeth, while other dogs had forty-two. The dog-like animals might be divided into two classes according to the peculiarities of the skull—those like the wolf, or the thooids, having a great cavity over the brow which causes the front to be prominent; and those like the fox, or the alopecoids, which are without this cavity. This enabled them to fix the position of the domestic dogs still more definitely; it would occupy a place in the series corresponding with that in which they had put the jackals and wolves. With regard to the stag-hound, the shepherd's dog, and many of the cur-dogs, no one would have the slightest hesitation in placing them just between the wolf and the jackal. Some domestic dogs had as large a development of skull as the wolf, but the appearance of sagacity it gave them could not be depended upon, for it was often due to the existence of the cavity. Speculating upon the probable origin of the domestic dog, Professor Huxley called attention to the fact that, in Northwest America, the Indian dog was not really distinguishable from the prairie-wolf. The domestication of these animals was easily explicable when it was remembered that, although fierce enough when stirred up, they were endowed with singular curiosity, which attracted them particularly toward man and his doings, and that, when caught young and kindly treated, they soon became as attached and devoted to their masters as ordinary dogs. A domesticated stock might thus have readily been produced. If this one domestic dog had originated in the taming by man of an indigenous wild animal, then the general problem of the original taming of domestic dogs would take this form: "Can we find wild stock so similar to the existing dog that there is no improbability in concluding them to be the same animals?" He thought we could. We might trace dog-like animals farther and farther west until, in northern Africa, we had a whole series of kinds of such animals usually known as jackals, presenting every conceivable gradation between the characteristic of the dog and the characteristic of the jackal. He believed these wild stocks were the source whence, in each region of the world, the savages who originally began to tame dogs had derived their stock. This was confirmed by the latest archæological evidence. The monuments of ancient Egypt had preserved a great variety of dogs, but it was an interesting fact that the oldest monuments contained the smallest number of varieties, and in the third and fourth dynasties there were only two well-marked forms of dogs—one a small, cur-like animal, resembling the one that now haunted the streets of Cairo, and the other of a form more like that of the greyhound. The cur was, no doubt, a tame species of the wild jackal, which was still to be found in the same country; and, with respect to the greyhound, there was in Abyssinia a very long-headed dog, which was very

much of the same form as the greyhound, and which it could hardly be questioned was the source from which it sprang. Assuming that the origin of the dogs could be traced to these sources, the more modified forms of the domestic animal were simply the result of the selected breeding which had given rise to similar modifications in dogs as it had done in the case of pigeons. Referring to the origin of dogs in general, Professor Huxley noticed the discovery of a fox-like animal of the Pleiocene period, which was found near the Lake of Constance. An animal, the cynodictus, lived in the upper Eocene period whose dentition was substantially that of the dog, and which appeared to bridge over the wide interval that separated the bears and animals of that order from dog-like forms. Beyond that period there was no distinct trace of dog-like animals. By the application of ordinary common-sense reasoning, which was verified every day by experience, they were driven to the conclusion that they could only attribute the origin of these animals to causes which operated in the existing course of nature. This left them to the simple alternative of the doctrine of evolution. He believed that small differences of form—slight modifications of one main plan—were amply sufficient to give rise to the existing dog-like animals, and that these modifications had actually taken place, starting from the cynodictus.

Efficiency of Lightning-Conductors.—Direct evidence as to the efficiency of lightning-conductors is afforded in a government report from Schleswig-Holstein, which is referred to in a recent work on the subject by Mr. Richard Anderson. Thunderstorms are said to be more numerous in Schleswig-Holstein than in any other part of central or northern Europe, and the danger from lightning is correspondingly increased. The attention of the government insurance-office was called to the fact that, in four out of 552 cases of claims on account of damage from lightning arising in eight years, conductors of approved design had been in use, and an expert, Dr. Holtz, of Greifswald, was appointed to inquire into the causes of failure. He found that, in every case where a building provided with a conductor had been struck by lightning, the conductor was not in an efficient state. Sometimes the point of the rod was needlessly ornamented with gilding, while the underground connection with the earth, the very element of safety, was neglected. In the absence of a proper ground connection, the lightning-rod, instead of being a protection, may prove the means of attracting the discharge into the building. A measure for the periodical testing of conductors is suggested, for the detection of defective constructions, interruptions of conductivity by rusting or displacement, or of other faults that may arise from time to time.

Atmospheric Currents and Carbonic Acid.—M. Marié Davy, of the Observatory of Montsouris, France, has made a report of observations which he has taken for four years on the proportion of carbonic acid in the air as it is related to the grand atmospheric movements. The quantity of this gas is found to vary from twenty-two to thirty-six parts in one hundred thousand parts of air. During the earlier observations, extending to December, 1877, the proportion of carbonic acid was below the mean, and sometimes fell very low. In a second period, from December, 1877, to September, 1879, the proportion was considerably above the mean. A third period began in October, 1879, which was characterized like the first period by a relative weakness of proportion. The weakness became remarkable in December. The second period, in which the carbonic acid was superabundant, was characterized by moist weather with a predominance of the equatorial current over France, and embraced two years of short crops. The first period was characterized by an inferior extension of the equatorial current, by less wet weather and better crops. During all of the time of the observations, the proportion of carbonic acid showed no variation to correspond with the changes of the wind or the indications of the barometer, thermometer, and hygrometer. The fall of rain had no definite effect on the proportion. It thus appears that the proportion depends on the general predominance of the equatorial current, and not on the temporary changes of weather.

An Electrical Experiment of the Eighteenth Century.—The apparatus here represented is composed of a globe of sulphur which a young abbé causes to turn by means of a crank and wheel, while the woman excites electrical action by means of the friction of her hand on the ball. A young man suspended horizontally by cords of silk becomes electrically excited, and causes the spark to fly from the end of his finger by



AN OLD ELECTRICAL EXPERIMENT.

putting it near a stick which another experimenter extends toward him. Experiments of this kind were much in fashion about the middle of the last century. They assumed many variations, but the one here represented was repeated frequently. The contrast between this simple apparatus and the hundreds of machines from the most delicate to the most powerful, applicable to a wonderful variety of purposes possessed by the electricians of the present day, helps us to realize the amazing rapidity with which improvements are made, and justifies the liveliest hopes for the advancement of electric art in the future.

Lessons from the Tongue of the Bee.—Professor A. J. Cook publishes, in the "American Bee Journal," some extremely interesting conclusions, which he has derived from the study of the tongue of the honey-bee. The accounts of the entomologists who have written upon the construction of this organ are conflicting and generally inaccurate. They do not agree as to its shape; some say that it is solid, others that it is tubular; some that the insects lap the liquids in which they feed, others that they take it by suction. By combining the studies that have been made by Mr. V. T. Chambers and Mr. J. D. Hyatt on the anatomy of the tongue of the bee with his own investigations, Professor Cook has been convinced that those who believe that the liquid is lapped up, that it is sucked through the tongue as a tube, and that it is drawn through a tube which is formed by the approximation of the ligula (or tongue), the palpi, and the maxillæ, are all right. The physiology of the tongue and the related organs adapts them to use in either of these methods; the bee has been detected in gathering nectar by all of them; and the presence of the fluid in passage has been demonstrated in the several organs the use of which is required by the different theories. The honey appears to be most abundantly secured by means of the tube formed by the closing up of the ligula, the palpi, and the maxilla. The ligula, or tongue, extends

several hundredths of an inch farther than the labial palpi, and is itself provided with a rod and slit which may be made a tube, and a funnel for gathering nectar. This instrument appears to be the only one which is available for use in gathering honey from small tubular flowers; and the examination of its construction explains why bees are so much longer in gathering from some flowers than from others, as those in which the combined tube is available. It is also probable that bees lap honey. The measurements of the tongues of bees show a uniformity in the length of those of bees from the same colony or apiary, but considerable difference in those of different breeds. In the same colony, tongue after tongue would show a variation of less than 0·25 of an inch from the base of the mentum to the tip of the ligula. The average length of the American black bee's tongue is about ·24 of an inch; that of the Italian bee is about ·02 of an inch longer. The longest tongues were found in some Cyprian bees. The difference in the length of the tongue is accompanied by a corresponding difference in the capacity of the bees for gathering honey. Honey in a vessel covered with fine gauze was placed before some Italian bees till they ceased to eat because they could no longer reach it. It was then placed before the black bees, but they could not reach it. A similar dish was given to the black bees first, and, after they ceased eating, the Italians continued to sip. Many trials gave similar results. This shows how the Italians can gather honey from flowers which fail to attract the black bees because the nectar is beyond their reach. It thus seems probable that the law of natural selection, which raised the Italian bees to their position of superiority, also gave them their longer tongues. Shut up in a narrow basin among the mountains, with only a limited range for food, competition must have been excessive among them, and the variations which gave any of them advantages over the others would come into the fullest play. Similar conditions may have determined the character of the Cyprian bees and other superior varieties of Europe.

The Violin: its Construction and Perfection.—In a lecture, which he recently delivered at the Royal Institution in London, on the construction, the history, and the sound of the violin, Mr. Haweis called attention to the variety in shape and style of instruments of the viol tribe, ancient and modern, as showing the inexhaustible fascination they possessed over the human mind. The wood was selected by the best makers of the old violins with extreme care. At Brescia, they used pear, lemon, and ash; at Cremona, maple, sycamore, "and, of course, pine. . . . The wood came into the markets of Mantua, Brescia, Cremona, Venice, Milan, from the Swiss southern Tyrol, unlimited in supply, often mighty timbers of great age—plentiful then, scarcer now. The makers had their pick; they tested it for intensity and quality. Cut strips of wood and strike them: you will see how they will vary in musical sound. When a good acoustic beam was found, the maker kept it for his best work. In Joseph Guarnerius and Stradivarius the same pine-tree crops up at intervals of years. A good maker will patch and join and inlay, to retain every particle of tried timber. Old wood is oddly vocal. As I sat in my room, surrounded by these instruments, I could not cough or move without ghostly voices answering me from the sixteenth, seventeenth, and eighteenth centuries; and even the old-seasoned backs and bellies of unstrung violins are full of echoes." Taking a violin and tearing it open, the lecturer continued: "The violin is made of fifty-eight or seventy pieces. It is a miracle of construction. It is as light as a feather and as strong as a horse. Wood about as thick as a half-crown, by exquisite adjustment, resists for centuries a pressure of several hundred-weight. The belly of soft deal, the back of hard sycamore, are united by six ribs of sycamore, supported by twelve blocks with linings. The sound-bar, running obliquely under the left foot of the bridge, is the nervous system of the violin; the sound-post, supporting the bridge, is the soul; through it pass all the heart-throbs or vibrations generated between the back and the belly; on its position depends mellowness, tightness, or intensity of sound. The prodigious strain of the strings is resisted first by the arch of the belly, then by the ribs, strengthened with the upright blocks, the pressure among which is evenly distributed by the linings which unite them,

and, lastly, by the supporting sound-bar and sound-post and back." The secret of the ancient varnish, on which some of the qualities of the instrument probably depended, is still only partly revealed. Mr. Haweis believes, with Charles Reade, that it was an heterogeneous varnish, first of oil with gum in solution, then of color evaporated in spirit. Dod, as late as 1830, had the recipe for something very like the Cremona varnish; and, lately, Mr. Perkins has analyzed the varnish of Joseph Guarnerius and found amber in it, and has himself produced varnish of an extraordinary quality. The supreme interest of the violin lies in its simplicity, beauty, strength, subtilty, and indestructibility, and, above all, in its perfection as a musical instrument. It combines accent with modification of sustained tone. The organ has sustained tone without accent, the piano accent without sustained tone, the violin accent and sustained tone modified at will. Within its limits it is scientifically perfect; it has all the sensibility, and more than the compass, execution, and variety, of the human voice. It is not an invention, it is a growth; it has come together, it is the "survival of the fittest." Its rough elements were selected from a variety of instruments which preceded it. Before the end of the fourteenth century viols were made in great profusion of every style and shape, but the rise of the true violin tribe begins with the rise of modern music. When the true octave and the perfect cadena had been discovered, and the human voice was found to fall naturally into soprano, contralto, tenor, and bass, viol instruments, adapted to these four divisions, were gradually separated from the confusion of instruments and brought to a perfection of adaptability.

A New Anæsthetic.—Bromide of ethyl is recommended by Dr. R. J. Levis, of the Pennsylvania and Jefferson College Hospitals, Philadelphia, as an anæsthetic preferable, in most respects, to ether and chloroform. It acts rapidly, and the patient recovers quickly from its effects. As far as observed by Dr. Levis, after several months of experience in using it, it does not influence the circulation except sometimes to produce a slight increase in the rapidity of the heart's action, and in arterial pressure. Respiration is but little affected by it beyond its producing the ordinary characteristics of all anæsthetic sleep; in this respect, its action seems more to resemble that of ether than that of chloroform. Nausea and vomiting occur less frequently with it than with ether or chloroform. It vaporizes readily, and seems to be entirely eliminated through the lungs, having, in this respect, a decided advantage over chloroform, which is not entirely removed from the system. Its vapor produces no irritation in the respiratory passages. General excitement and the tendency to struggle occur far less frequently when it is used than in the early stages of the anæsthesia of ether, and, apparently, even than in that of chloroform. Complete anæsthesia is accomplished, it is estimated, in about one third less time than is the case with chloroform, and recovery from the effect is even comparatively more rapid, the time required for recovery generally not exceeding two minutes after the inhalation has ceased. The recovery is so complete that the patient is often able to stand and to walk immediately after awakening. Insensibility is usually produced in from two to three minutes. The longest period that has been required in Dr. Levis's practice was four minutes, the shortest one minute. The completion of the effect is clearly shown by the dilatation of the pupils of the eyes, which resume their normal condition when the sentient state returns. The vapor of this substance is not inflammable, so that it is free from the danger which attends the use of ether at night when lights are around. The ordinary essentials of the proper and safe production of anæsthesia must not, however, be dispensed with in the use of the new agent, for its safety is only comparative, and is not yet proved to be absolute. Dr. Levis, who acknowledges his indebtedness to Dr. Lawrence Turnbull, of Philadelphia, for the suggestion of this agent, now uses the bromide of ethyl, to the exclusion of other anæsthetics.

Slave-making Ants.—It may be edifying to such persons as take pride in physical prowess to know that on the battle-field ants distinguish themselves quite as signally as

do human beings. Mrs. Mary Treat, in the "American Naturalist," thus describes a contest which she witnessed between slave-making ants and black ants: The former were the aggressors, and victorious. The two colonies were one hundred and twenty feet apart. An idea of the numbers constituting the ranks of the slave-makers may be gathered from the fact that on the war-path, one hundred and twenty feet in length and a foot wide, they "were not thinly scattered, but a vast moving phalanx." The blacks, a grand army on their own territory, would not flee. The battle-field was about twenty-five feet in circumference. A roar announcing the beginning of hostilities lasted for five minutes, "whereas the battle lasted four or five hours before the reds gained possession of the vast nurseries of the blacks," and it took two days to carry the pupæ and prisoners to their own dominions.

Epidemics.—Sir Joseph Fayrer, in his address delivered before the Epidemiological Society of London, on the subject of epidemics, gives some interesting facts regarding typhoid fever and cholera in India. It is well known that typhoid fever is a prolific cause of mortality among European soldiers there, and questions of great practical importance arise in regard to the age, time, and seasons for sending men to the army in India. It appears from the statistics that this disease tells most severely upon the young men during their first year of service; and Dr. Fayrer raises the question as to whether this fever, so prevalent in India, is identical with the disease which might be contracted in London, New York, or Dublin, from water-closet, drain, sewer, or well. He is of the opinion that these fevers are often the same, but that more frequently they are not, and that in hot, malarious countries climatic causes give rise to fevers identical with the others, except that they can not be traced to filth or other specific cause. But, while recognizing that but little is known of the nature of epidemics of this class, he asserts that the past twenty years show great progress in ability to successfully cope with them. He says, "Science that has enabled us to reduce the death-rate among our troops from 17·9 to 8·56 per 1,000 in Europe, and from 69 to 17·62 per 1,000 in India, speaks for itself, and, were there no other results, this alone is a triumph such as has not been achieved by other departments of knowledge." As a result of better sanitary conditions among European troops the following alteration in the death-rate is shown: from 1861 to 1865, 9·02 per 1,000; 1865 to 1870, 6·98; 1870 to 1875, 3·23; 1875 to 1876, 2·3; 1876 to 1877, ·84. In allusion to the history and treatment of cholera the doctor says: "All serves to show that it is the same now as formerly, and that, though we have gained much knowledge of its natural history of late years, yet we are as ignorant as our predecessors of its real nature. We have, thanks to sanitary measures, disarmed it of some of its terrors, and have diminished the mortality it caused; but as to treatment we have gained but little, though the empiricism of to-day is more scientific than it was in former days. We do not now burn our patients on the soles of the feet, tie ligatures round their limbs, or have recourse to other senseless barbarities; for we find that simpler and more rational methods are of greater avail, more or less according to the period of the epidemic attack, and the promptitude with which the remedies are applied. But we have learned that local causes have a potent influence, and that cleanliness, good air, *pure water*, and free ventilation, are all powerful opponents of cholera."

Danger of the Hypodermic Use of Morphia.—The danger of using morphia in hypodermic injections has been again forced into notice by the recent death of the Italian Consul at Bombay, India. His physician had prescribed two "grana" of morphia as a remedy for a pain in his leg from which he was suffering. The chemist mistook the word "grana" for "grammes" and gave fifteen times as much morphia as was intended. The mistake was discovered at once and remedies were applied, but the patient sank rapidly and died the same evening. The peculiar risks of the hypodermic use of morphia arise from the facts that an overdose once administered can not be recalled, and that no means exist of ascertaining how large a dose the patient can

bear. An excessive quantity of morphia given by the mouth may be removed if the accident is discovered immediately, but the only resource in case of excessive injection lies in antidotes, the operation of which is very uncertain. According to the collection of facts on this subject which has been published by Dr. Kane, of this city, the smallest single dose which has appeared to have alone been the cause of death was a quarter of a grain. In a case in which death apparently resulted from the administration of a twelfth of a grain by the skin, a quarter of a grain had previously been given by the mouth. In three of the cases cited by Dr. Kane, including one in which a quarter of a grain caused death, the patients were suffering from delirium tremens; in the majority of the cases the fatal effect was due to the repetition of the hypodermic injection, or to its employment after a fair dose of opium had been given by the mouth. It is impossible to predict, or to estimate with any approach to safety, what the effect of an injection will be. Tolerance of opium by the mouth does not prove that it will be tolerated equally well by the skin; and tolerance of morphia by hypodermic injection at one time is no ground for inferring that at another time the same dose would be equally well borne. The use of morphia is peculiarly dangerous in certain morbid states, foremost among which is alcoholism. The existence of chronic Bright's disease increases the danger, as does also the existence of disease of the heart or lungs, interfering with circulation and respiration. The fact also seems to be established that the existence of severe pain does not render large doses better borne. Atropine is capable to some extent of counteracting the influence of morphia, but can not be relied upon alone. It needs to be supplemented by other remedies, and is assisted by the hypodermic injection of strychnia. It also will kill, and should not be used in a larger proportion than one twenty-fifth of a grain of atropine to every grain of morphia. Strychnia should not be used in a larger total quantity than one twentieth of a grain, and a much smaller dose should be first administered. Artificial respiration, electricity, and coffee or caffeine, remedies in common use, may also be necessary in addition. Whenever there is reason to think that the injection has been directly into a vein, the circulation in the limb should be arrested by a ligature above the place of injection; and the "Lancet" suggests that it is possible, when the fact of an overdose is at once discovered, that something may be done by local treatment to arrest absorption. The whole of the morphia can hardly be taken up instantaneously, and it is probable that, if a ligature were at once placed on the limb, an incision made through the skin at the seat of the injection, and the part freely washed, or even freely cauterized, the amount of morphia absorbed might be reduced to so small a degree that it would be possible to antagonize it, and thus save the patient's life.

Sanitary Perils at Watering-Places.—The "Lancet" has uttered a warning against the sanitary dangers to which populous health resorts are liable, which receives support from several incidents that have happened within a few years past. It is incumbent upon every one who goes to the seaside, to take care that he does not leave a comparatively healthy home to seek recreation in a place which may be a nursery of disease. Watering-places are peculiarly liable to have two kinds of perils: to the danger that infection may be brought to them by visitors, and to the risks that may arise from the insufficiency of their sanitary arrangements to meet the demands that are made upon them by the accession of large crowds. It has sometimes happened that, as soon as a child has become convalescent from an infectious disease, it has been hurried off to the seaside, and been received at lodgings without question. The sanitary precautions now carried out at many places make this a matter of more difficulty than formerly, but the danger is still hardly diminished that arises from sending off the unaffected members of an affected family to the seaside as soon as contagious disease breaks out. The "Lancet" tells of a case as having come under its own notice, in which, when a child was taken ill with a sore-throat of a suspicious character, another child in the family was sent to the seaside, was taken ill with diphtheria on the day after his arrival, and communicated the disease to other children with whom he had played. When disease breaks out in the height of the season, the fact is apt to

be concealed as long as possible, and unknowing visitors continue to go down as into a trap. "Not long ago," again says the "Lancet," "family after family went down to one of our [English] largest seaside towns, to be infected with scarlet fever, the existence of which at the place was carefully concealed." The dangers arising from imperfect sanitary arrangements at these resorts and in the lodging-houses have been much discussed of late, but the agitation ought to be kept up without intermission till they are all remedied. The question of drainage, which is a difficult one anywhere, is no less difficult at seaside resorts than at other places. The most natural measure is to carry the sewage to the nearest and most convenient spot at which it can pass into the sea, and this is often the place where visitors and loungers will be most exposed to its emanations. The case is still worse on lakes, for there the slowly moving water becomes charged with sewage; and cases of illness have been known to arise from boating in the neighborhood of the discharge-pipes. Many physicians have had experience with diseases arising from filth that have been contracted at the seaside, and cases of typhoid fever originating in such places have been noticed in England as well as in the United States. That sickness is not more general is doubtless due to the fact that visitors spend so much time in the open air. If they lived there as they do at home, they would, perhaps, find many of these places the reverse of "health resorts."

Rhythmic and Colored Lights for Lighthouses.—Sir William Thomson urges a threefold reform in the British lighthouse system, viz.: "A greater quickening of nearly all revolving lights; the application of a group of dot-dash eclipses to every fixed light; and the abolition of color as a distinction of lighthouse-lights, except for showing dangers and channels and ports by red and white and green sectors." He observes that, in revolving lights of which the period is ten seconds or less and the time of extinction seven seconds or less, the place of the light is not practically lost in the short intervals of darkness, the eye sweeping deliberately along the horizon to "pick up the light, passes over less than the breadth of its own field of view in the period of the light, and thus picks it up almost as surely and quickly as if it were a fixed light. Compass-bearings may also be taken with these quick-revolving lights almost as easily and accurately as if the light were continuous. The distinction by color alone ought to be prohibited for all lighthouse-lights, on account of its liability to confusion with ships' and steamers' side-lights. In place of color, Sir William would distinguish every fixed light by a rapid group of two or three dot-dash eclipses, the shorter, or dot, of about half a second duration, and the dash three times as long as the dot, with intervals of light of about half a second between the eclipses of the group, and of five or six seconds between the groups, so that in no case should the period be more than ten or twelve seconds. The Holywood Bank Light, Belfast Lough, until 1874 was inclosed in a red-glass lantern, was only visible for five miles, and was constantly liable to be taken for a sailing vessel's port-side light. In 1874 the red glass was removed, and the light was marked by a dot, dot, dash (. . —, or letter U of the Morse flashing alphabet), repeated every ten or twelve seconds, and has been so ever since. It is now recognized with certainty as soon as seen in ordinary weather from the mouth of the Lough, ten miles off, and has proved most serviceable as a leading light for ships bound for Belfast or entering the Lough. Sir William Thomson's objection to colored lights is corroborated by Mr. J. P. Thompson, who relates, in a letter published in "Nature," how he narrowly escaped shipwreck off the Cornish coast by inability to perceive the red flashes of the "Wolf" light, which seemed to have been neutralized by the fog, or from the daze caused by the phosphorescence of the sea.

A Singular Root-Growth.—A correspondent of "Die Natur" describes a singular form of growth of fibrous roots, which he and his associates observed in opening one of the ancient-burial places, called cromlechs, at a town in the province of Posen, Prussia. Along with other objects usually found in such burial-places, they noticed several urns, filled with ashes, calcined bones, and sand, and all closed with a cover shaped

like a basin, and fitting tightly over the rim of the urn. They took off the covers and emptied the vessels, when they were astonished to find that the surface of the sand in one of them was apparently covered with a deep-black peruke, ornamented with pearls of about the size of a pea. A more careful examination showed them that this curiously discovered "head-dress" was composed of the fibrous roots of the horse-tail rush, which grew abundantly on the top of the hill in which the graves had been made. The roots of the plant having penetrated the soil to the depth of three feet and a half, had made their way through the narrow crevices between the stones of the grave, had found the urns, had then pushed up perpendicularly through the minute space between the rim of the cover and the neck of the urn, and had arranged themselves within the urn into a regular network. After the formation had been dried, the course which the principal root had taken could be traced. The fibrous roots had branched out from it, and covered the whole surface of the sand in such a manner as to deceive the observers for a time with the resemblance to a beautiful head-dress. The knots, which were taken for pearls, were irregularly distributed, and were manifestly thicker in places in the principal root. The formation affords an interesting illustration of the faculty which the roots of plants possess of seeking for and reaching the most suitable nourishment. The operation in the present instance involved a reversal of the common direction of the growth of roots, and that which resembled an effort to reach hidden food. The case furnishes a curious parallel to the one which was described in this country a few years ago, in which the root of an apple-tree, which grew over the grave of Roger Williams, was found to have taken the place and shape of the body buried below.

Artesian Wells on our Western Plains.—A proposition to make an appropriation of fifty thousand dollars for the purpose of sinking experimental artesian wells in the Western Plains, has been advocated in Congress, and has been mentioned favorably in the press. It is urged in behalf of the scheme that of about nine hundred million acres of arid lands in Arizona, Dakota, Idaho, Montana, New Mexico, Utah, Wyoming, Colorado, and Nevada, which must remain practically a desert unless some method is found to supply them with water, about five hundred million acres of plain and valley lands would be susceptible of profitable cultivation if they could be watered. Of this, not more than three per cent. can be irrigated by the use of existing streams and rivers. It has been demonstrated, wherever settlement has been made and irrigation applied, that the lands when watered are as good as any; and the operations of the French in Algeria, which are still continued, give an encouraging promise of what can be accomplished with artesian wells.

African Fetich-Worship and Witchcraft.—Dr. Buchholz, a German entomologist, in his account of his wanderings in west Africa, notices many of the peculiar customs of the negroes of Upper Guinea, particularly those relating to fetich-worship and witchcraft. While among the Akkra tribes of the Gold Coast, he found that fetiches, generally clay dolls representing a man and a woman, had been laid at the foot of the termite-hills which he was interested in examining, with offerings around them. The fetich-processions are celebrated with considerable pomp, in which the fetich-drum, a stick provided with rings on which a little hollow ball, a gourd-shell, is rapidly struck, plays an important part. At the village of Abreri, farther inland, the ceremonies were held in a large, open place, at one end of which silvered images of the gods, rude figures representing a bird, a turtle, an ear of corn, and a figure holding different vessels, were set up in an orderly manner on a pillar, while the priest performed his ritual at the other end. The music, of drums, bells, and other instruments, including a drum of bronze, was accompanied by the multitude with a rhythmical hand-clapping. At the feast of the new moon, in addition to the music and the singing, each participant had a white streak drawn over his face, and the master of ceremonies, swinging a peculiar brush and gesticulating frantically, had his face painted all over white. The Bakhniri believe, when any one dies or is sick, that he has been bewitched; or if

death is caused by a snake, or a crocodile, or a leopard, that the animal has been bewitched to cause it. The person accused of witchcraft is compelled to drink a decoction of a poisonous wood called sassha-wood; if he vomits up the drink, he is considered not guilty and let go; otherwise, he is killed if he does not die of the poison. They have a great fear of white people and all that comes from them, and especially regard paper that has been written upon as a fetich and the place or the thing on which it falls as *taboo*. When Dr. Buchholz on one occasion dressed the wounds of a sick person, he let a little piece of paper fall out of his pocket without noticing it. When he next went to visit the sick man, he found that his patient had been quarantined because the house was considered bewitched, and the piece of paper was ceremoniously handed back to him. One day, when a woman was to be buried, the negroes sent a messenger to him with a special request that he would not leave any pieces of paper anywhere that he went, because, if he did, they would have to keep away from those roads and places. A son of old King William, of Bimbia, having died after a long sickness, an innocent man was accused of having caused his death by witchcraft. He was taken out and hung; immediately the whole population, men, women, and children, ran to the shore, stripped off the little they had on, and went into the water to wash off whatever enchantment might be on them. One of the festivals among the Deialla negroes was diversified by an exhibition of single combat. The champion who achieved the most brilliant victory was hailed with great applause, and his mother sung and danced to his honor; but one of the defeated ones went up to his mother and reproached her because she had not given birth to a stronger son.

A Remarkable Coal-Mine Explosion.—M. A. Delesse gives in "La Nature" an account of an explosion of carbonic acid which took place in a coal-mine at Rochebelle, France, on the 28th of July, 1879. Two workmen, who were at the bottom of a shaft about three hundred and seventy-five yards deep, heard a sudden detonation, which was followed in about a minute by another louder one. Their lamps were instantly put out; they felt a faintness, and were barely able to escape to the hoist-car and be drawn out. Three other miners, who were working in a gallery ninety yards higher, were suffocated. The scene of the disaster was afterward examined, and it was decided that the explosions could not have proceeded from carburetted hydrogen, for they were not accompanied by flames; thin partitions in the shaft and upper galleries were not broken; the bodies and clothes of the dead men showed no signs of having been burned; and powder which lay in the gallery and in cartridges had not taken fire. No signs of carburetted hydrogen had ever been observed about the mine, but carbonic acid had always been present, sometimes in such quantities as to compel the men to cease work, and a ventilating apparatus had been put up to discharge it. The explosion was found to have taken place in front of the excavations in one of the upper galleries (two hundred and sixty-six yards below the surface), which was obstructed for a considerable distance by the broken coal. Small particles and dust were thrown out to a much greater distance, and the man who was working in front had been thrown back and buried under the fragments. About seventy-six tons of coal appear to have been displaced by the explosion. Carbonic acid continued to escape from the coal after the accident, and even the pieces that had been thrown into the gallery gave it out when they were disturbed. No satisfactory explanation has been offered of the manner in which the gas could have accumulated, and have gained so high a pressure as to cause a detonating explosion. The gas, it is suggested, may have been formed by the action of the sulphuric acid which escapes from a vein of rapidly oxidizing iron pyrites in the neighborhood upon an adjoining bed of limestone, but this leaves the question of a violent explosion still unsolved.

A Systematic Investigation of Earthquakes.—The Swiss Natural History Society has appointed a special commission of seven members for the systematic observation of earthquakes. Recognizing that a large number of observations at as many

places as possible is necessary for the sufficient investigation of every earthquake, the commission has taken measures to enlist those persons generally in its own country who are interested in investigations of this kind in coöperation with its work, and is perfecting a special organization for the collection of observations with the aid of such assistants. A special field is assigned to each member of the commission, and he is expected to put himself in communication with persons who may be disposed and competent to aid him in different parts of his district. A tract for distribution has been published under the direction of the commission, which contains a summary of the most recent facts that have been ascertained about earthquakes, and points out the directions in which an increase of knowledge on the subject can be promoted. A number of stations, selected by the commission, are provided with instruments for special observations. The observers are furnished with a schedule of questions respecting the different phases of the earthquakes they may witness, which they are expected to answer as fully as they are able to do. They are also requested to represent the phases of the shock graphically on a chart, where it is possible, to assist in comprehending and reviewing the character of the phenomena. The collected accounts of observations are arranged and preserved in an archive of earthquakes. As the questions concern a subject of general interest, and are useful aids to investigation everywhere, we repeat them entire. They are seventeen in number, as follows: 1. On what day was the earthquake noticed? 2. At what hour? 3. How did your clock agree on the day, or, better, on the hour, of the earthquake, with the nearest telegraph clock? 4. Endeavor to furnish an exact description of the place of observation, the canton, town, situation, whether in the open or among buildings, in what story of the house; state in what position and what occupation the observer was when the shock was perceived? 5. On what kind of soil does the place of observation stand? Whether the surface be of rock, soil, or peat; depth of the ground to bed-rock, etc.? 6. How many shocks were felt, and during what interval of time? 7. In what direction was the motion? Did it come from below, was it short and in a direction from side to side, or broad, surging in the form of waves, or only a trembling? In case there were more than one shock, was there a difference in the character of the different shocks? With what could the motion be compared, and how did it affect the observer? 8. In what direction was the trembling of the earth felt? 9. How long did the shocks and the subsequent trembling seem to last? 10. What effects did the shaking produce? 11. How might this earthquake be distinguished from others which have previously been noticed by the same observers? 12. Was any noise heard, and, if so, what kind of a noise was it—like thunder, a clinking, a rattling, a clap, or a continuous noise, etc.? 13. Did the noise precede the shaking or follow it, and how long did it last in comparison with the duration of the shocks and of the intervals between them? 14. What particular minor phenomena were observed? Were there, for instance, anything peculiar in the behavior of animals; any drying up, or troubling, or breaking out again of springs; any peculiar rustling in the woods, any gusts of wind simultaneous with the shocks, or abnormal features of the weather? 15. What was noticed with regard to the lakes? 16. Were lighter shocks felt before or after the main shocks, and at what time? 17. Can you mention any other observations made by your acquaintances or in your neighborhood, or can you give the addresses of persons who are able to answer all of these questions, or a part of them?

Precocity a Sign of Inferiority.—M. G. Delaunay, in a communication to the French Société de Biologie, has advanced the opinion that precocity is a sign of biological inferiority. In support of his position he adduces the fact that the lower species develop more rapidly, and are at the same time more precocious, than those higher in the scale. Man is the longest of all in arriving at maturity; and the inferior races of men are more precocious than the superior, as is seen in the children of the Esquimaux, negroes, Cochin-Chinese, Japanese, Arabs, etc., who are, up to a certain age, more vigorous and more intellectual than

small Europeans. Precociousness becomes less and less in proportion to the advance made by any race in civilization—a fact which is illustrated by the lowering of the standard for recruits, which has been made necessary in France twice during the present century, by the decreasing rapidity of growth of the youth of the country. Women are more precocious than men, and in all domestic animals the female is formed sooner than the male. From eight to twelve years of age, a girl gains one pound a year on a boy, and in mixed schools girls obtain the first places up to the age of twelve. The inferior tissues and organs develop before the higher ones, and the brain is the slowest of all organs to develop. M. Delaunay concludes his paper by stating that the precocity of organs and organisms is in an inverse ratio to the extent of their evolution.

NOTES.

ACCORDING to Dr. Abercrombie, a gentleman who had been a soldier dreamed that he heard a signal-gun, saw the proceedings for displaying the signals, heard the bustle of the streets, the assembling of troops, etc. Just then he was roused by his wife, who had dreamed precisely the same dream with this addition, that she saw the enemy land and a friend of her husband's killed; and she awoke in a fright. This occurred at Edinburgh, at the time when a French invasion was feared, and it had been decided to fire a signal-gun at the first approach of the foe. The dream was caused, it appears, by the fall of a pair of tongs in the room above; and the excited state of the public mind was quite sufficient to account for both dreams turning on the same subject.

THE French forestry department, according to the "Polybiblion," have arrived at the conclusion that forests directly increase the supply of water in their neighborhood. From observations at Senlis and Nancy, they have decided that it rains more abundantly in wooded tracts, and that, while the leaves and branches give back the water quickly to the air, they prevent rapid evaporation from the ground, and are thus favorable to the formation of springs.

DR. LUDWIG MOSER, Professor of Physics in the University of Königsberg, died in the latter part of February, aged seventy-five years. "Long," says "Nature," "before photography had become a practical art, Dr. Moser had acquired considerable reputation by his systematic and successful experiments in this department."

SPECIMENS of the volcanic ashes which rained down upon Dominica have been analyzed by M. L. Best. The lye was found to be rich in chloride of potassium. The predominant constituents of the solid part were silicates (feldspar and pyroxene), and pyrites in perfectly defined cubic crystals.

ANOTHER severe outbreak of scarlet fever, which occurred near Manchester, England, last summer, and in which thirty-five persons belonging to eighteen different families were attacked, twenty-five within thirty-six hours, has been traced by the health authorities to the distribution of the infection through the milk-supply.

HERR BAUMGARTNER, a German, has invented a balloon for navigation, having three cars attached, each with ten or twelve rings, to be set in motion by a crank. He recently attempted an ascension with his machine at Leipsic. When the balloon was rising very slowly and skimming the house-tops his two assistants, in their alarm, jumped out. Upon this the balloon shot up to a great height, then burst and fell. The inventor was not seriously hurt, and is resolved to make a second experiment.

REV. JAMES CLIFTON WARD, F. G. S., from 1865 to 1878 an active working member of the English Geological Survey, and a popular writer on geological subjects, died April 13th, at the early age of thirty-seven.

"NATURE" quotes from the "Bombay Gazette" an account of a remarkable thunderstorm that occurred at Dharwar, in March last, during which "hailstones fell measuring no less than nine or ten inches in circumference." The thunder and lightning were terrific, and, after the fall of hail, there was a heavy down-pour of rain. We thought the hailstones mentioned above were the largest ever heard of, but it turns out, as usual, that the West is ahead in hailstones as well as meteors and other celestial commodities. The "Bulletin" of the Iowa Weather Service, for April, 1880, received since the above was written, tells of thunderstorms during the month, in that State, where hailstones fell measuring *twelve* inches in circumference.

THE death is announced of Karl von Seebach, the distinguished Professor of Geology at Gottingen. Although still a young man at the time of his death, he had done a large amount of valuable work, especially in the investigation of volcanic phenomena.

A SCIENTIFIC association has been formed in Algeria on the plan of the British and

American Associations, and has already enrolled one hundred and fifty members. Its first bulletin contains a paper on the fevers of Algeria, which affords the most satisfactory evidence that a great improvement has been made in the sanitary condition of the country, by the operation of the hygienic measures which have been carried out by the civil and military authorities, consisting of the clearing of the ground, drainage, plantations of trees, etc. During the thirty years from 1845 to 1875 the death-rate of the European population fell from 50 to 38 per thousand inhabitants. The diminution of mortality is shown in a still more striking degree in the army, where it fell from 77·8 per thousand men between 1837 and 1846, to 12·3 per thousand in 1876, and 12·5 in 1877. These proportions are very near to the rate of mortality in the interior of France itself, which was equivalent to ten deaths among a thousand effective men during 1876.

PROFESSOR BOYD DAWKINS, F. R. S., of Owens College, Manchester, has engaged to deliver a course of lectures on "Primitive Man," at the Lowell Institute, Boston, in October and November of this year.

M. RAOUL PICTET recently delivered a lecture in Paris on "Cold and its Applications to Science and Industry," in the course of which he struck a medal with fifteen kilogrammes (or thirty-three pounds) of solidified mercury.

THE case mentioned by Dr. Coues of a breed of one-toed hogs has a parallel in that of a one-toed deer, the feet of which were recently presented to the California Academy of Sciences. The third toe is described as the only one used for progression, though there were different degrees of development in the respective feet.

MR. THOMAS BALL, F. R. S., F. L. S., died at Selborne, Hampshire, England, on March 13th, aged eighty-seven. He was for a long time Professor of Zoölogy at King's College, and the writer of several works on natural history. The last eighteen years of his life were spent at the breakers at Selborne, the former home of Gilbert White the naturalist, which he purchased, and made the repository of numerous memorials of White, that, with the house and grounds, were always kept open to visitors.

A COMMISSIONER of the London "Morning Post," who has been examining the condition of the Riviera between Cannes and San Reno, reports the existence of an interesting state of things in that famous health resort. There are no sewers; cesspools are universal, and so placed as to be sources of danger to the inmates of the houses; public water-supply there is none, and the rain-water drains, which are also conduits for the cesspools, have slight gradients, are never flushed, and are generally the sources of foul emanations; and, to cap all, the beaches and promenades near the sea are soaked with sewage which also chokes the almost tideless bays.

ARTHUR JULES MORIN, born in Paris, October 17, 1795, died in that city on the 7th of February last, in his eighty-fifth year. Besides a brilliant military career, in which he reached the position of artillery general of division, he was distinguished as an investigator, chiefly in the field of mechanics. He also possessed executive abilities of a high order, and held for thirty years the directorship of the Conservatoire des Arts et Métiers, which, under his administration, became the leading school for the artisan classes in Paris. He was president of the commission for the first Universal Exposition held in the French capital; in 1862 was elected President of the French Society of Civil Engineers, and has been a member of the French Academy of Sciences since 1843.

MR. C. W. SIEMENS, pursuing his observations on the influence of the electric light on vegetation, finds that, by its use, the growth and ripening of fruit may be greatly hastened. At a recent meeting of the Royal Society of London, he exhibited two pots of strawberries which had been grown in the usual way until the fruit-buds appeared, when one was exposed to daylight during the day and the electric light at night, the other being left to the influence of ordinary daylight alone. The former, or the one exposed to continuous light, bore a bunch of large, red, fragrant berries, while on the other the berries were still green with the exception of one, that bore a slight red spot.

DR. WILLIAM SHARPEY, M. D., F. R. S., the eminent physiologist, died in London, April 11th, at the age of seventy-eight. He graduated in medicine at twenty-one, practiced a short time, and then went to the Continent for the purpose of continuing his studies. Subsequently he returned to Edinburgh, and began to lecture on anatomy; and, five years later (1836) was appointed to the chair of Anatomy and Physiology of the University of London (now University College), which he occupied for thirty-eight years. During this period he became celebrated as a teacher and original investigator, and, though not a voluminous writer, his contributions have always held a high place in the literature of these departments of science. He was for some years Secretary of the Royal Society, and, from 1840 to 1863, Examiner in Anatomy and Physiology to the University of London.